3ÈME PARTIE

APPENDICES

(1932—33)

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Some Observations on Fry in Trawl Catches in the Barentz Sea.

By

Capt. Thor Iversen, Bergen.

As early as the year 1900 Dr. Johan Hjort called ttention to the fact that, during the summer, reat swarms of pelagic fry of the gadoids drifted orth with the ocean currents into the Barentz Sea n order, later on, during the winter, to seek bottom n the different areas both along the coasts and at ne greater depths of the banks. Hjort has explained his condition more thoroughly in his publication: Fishery and Whaling" 1902.

In "Rapports et Procès-Verbaux", Vol. X, 1909, r. Damas has published a report which deals with very extensive material of gadoids collected on the ruises of "Michael Sars". There are, among other ings, tables giving measurements of trawl catches cod from different areas of the Barentz Sea, and ese tables illustrate clearly the occurrence of conderable amounts of cod fry in sizes down to 11 cm.

Later investigations, based on material collected n the cruises of "Michael Sars" during a period of ears up to and including the year 1914, have further roved the presence of great quantities of fry in arious regions of the Barentz Sea. These catches of y have been accomplished partly by means of smallced fish trawls (50 feet headline), especially conructed for the capture in addition of very small ecimens. The fry has partly been caught by means shrimp trawls with fine mesh, partly on lines, nd gear and seines.

The Norwegian Ocean Investigations in these orthern waters ceased at the beginning of the war 914), but they were resumed in 1923 with vessels red for the purpose, and have since been continued ery year except in 1927.

During these later investigations considerable ounts of fry have also been observed in the Barentz a and northwards to the banks of Björnöya and rther along the western and northern coasts of itsbergen. On these later cruises, true enough, it s been observed that spawning of cod and haddock kes place farther north than previously conceived. the Björnöy Bank, particularly on the western pe of the bank, spawning cod have been caught l eggs of cod and haddock have been found drifting the surface water. Likewise spawning cod have n caught on the edge of the bank west of Isefjord, tsbergen. However, the main part of adult cod ght in these localities during spring included fish ose sexual organs proved that they had not wned or were to spawn that year, the so-called elltorsk" ("Gill-cod").

This spawning of cod and haddock in the Barentz must, however, be regarded as being insignificant en compared to the amount of fry necessary in er to stock this area with the great abundance really existing here, and does in no way shake the theory that fry of cod and haddock in the Barentz Sea are mainly transported from southern spawning grounds.

The appliances used by these hired vessels have been shrimp trawls, seines, lines and hand gear until the winter 1932—33. The fisheries investigations were accomplished during December—January—February with the hired steam trawler "Borgenes" and, besides lines and hand gear, also fish trawl was employed. The latter is of the ordinary normal size now used by the British trawlers in the northern waters.

By the employment of this large fish trawl an occasion was offered of a more accurate examination of the catches obtained by an ordinary fish trawl. On account of the season with bad weather, darkness and frigid temperatures it was not possible to determine accurately the contents of each haul, but some of them were examined so closely — particularly in regard to cod and haddock — that I have been able to construct tables which show the number of marketable cod and haddock and the number of non-marketable, valueless cod and haddock.

On the end portion (cod end) of the bag of the trawl a little piece of fine meshed net was attached. This net collected, partly, the smallest individuals which otherwise escape through the mesh of the trawl. In the tables constructed, however, these smaller specimens, caught in the fine meshed net, are not counted in the compilation of the numbers of marketable and non-marketable cod and haddock.

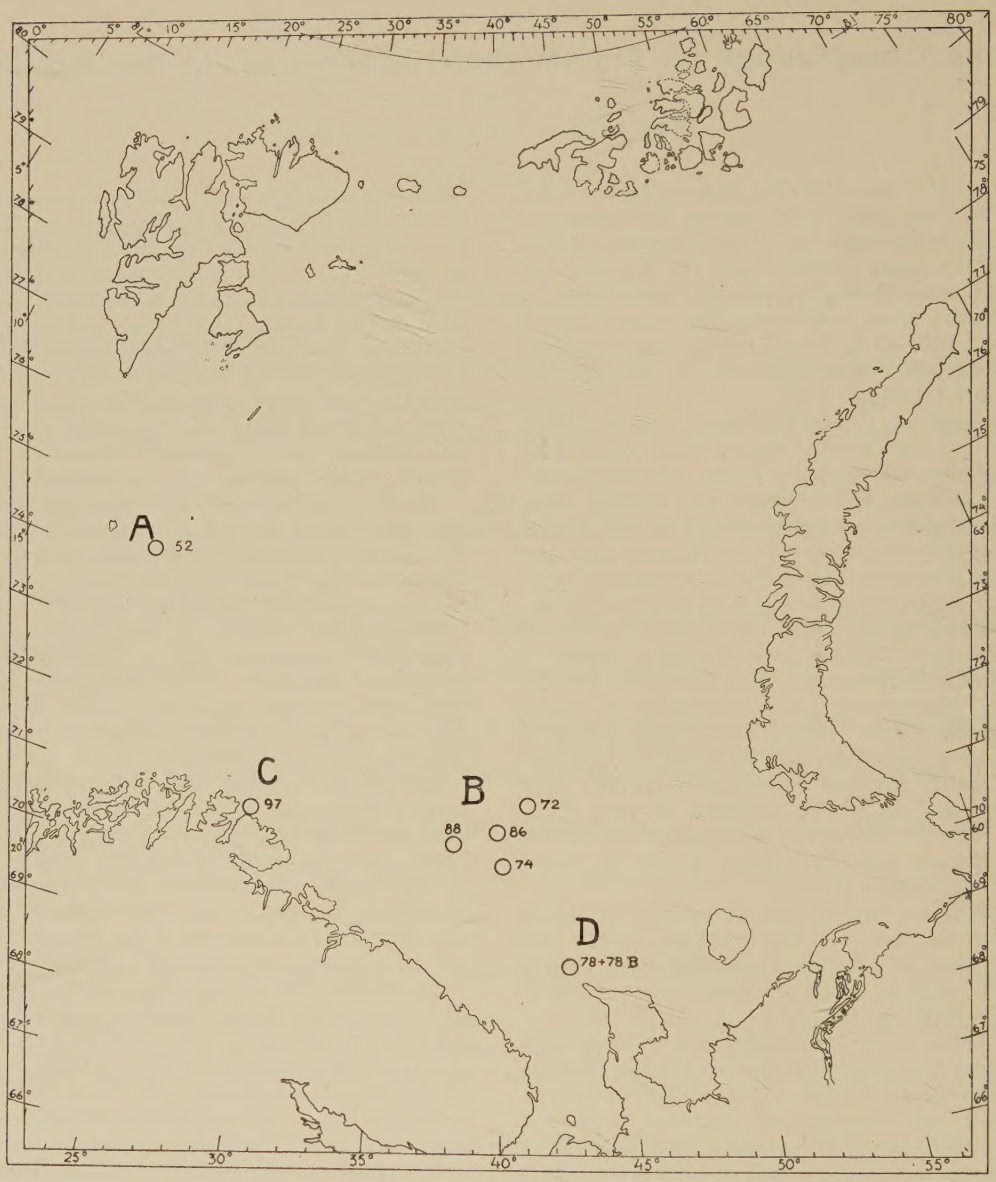
The tables give an impression of the trawl catches in 4 main areas in the Barentz Sea during winter, i. e. Björnöy Bank — the central portion of the Barentz Sea (around Skolpen Bank) — the edge of the Bank off Finnmark (Tanasnaget) and the Shallow Bank off Cape Kanin at the entrance to the White Sea.

It appears that the trawl catches contain large quantities of smaller fish of several species which are killed and thrown overboard. Especially in regard of cod and haddock the amount of small and non-marketable fish in proportion to the total catch varies in the different areas.

The content of non-marketable cod and haddock in the trawl catches:

A. Björnöy Bank: December 12th 1932. Depth 220 m. Non-marketable cod 98.4 %. Haddock 0 %. Total 98.4 %. Catch: 766 cod, 0 haddock. (In the fine meshed net in addition 191 cod, 5 haddock.) One single haul.

B. Central Portion of the Barentz Sea. Jan. 1st to 7th 1933. Depth 156—210 m. Non-marketable



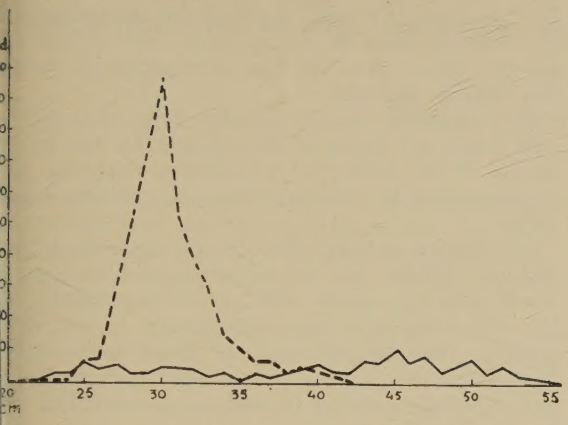
Survey chart.

cod 53 %. Haddock 91.1 %. Total 68.8 %. Catch: 3952 cod, 2821 haddock. Total 6773 individuals. (In the fine meshed net in addition 339 cod, 372 haddock.) 4 stations with a total of 6 hauls with catches of non-marketable cod and haddock varying from 61 % to 87.5 %.

C. Edge of the Bank off Finnmark. Jan. 9th to 11th 1933. Depth 105—230 m. Non-marketable cod 43.3 %. Haddock 53.6 %. Total 45.6 % Catch: 2820 cod, 827 haddock. Total 3647 individuals. (In the fine meshed net in addition 80 cod, 245 haddock.) 1 station with 7 hauls; catches of non-marketable cod and haddock varying from 23.9 % to 65.9 %.

D. Shallow Bank off Cape Kanin. Jan. 3rd t 5th 1933. Depth 63—65 m. No non-marketable co and haddock. Catch: 686 cod, 1450 haddock. Tota 2136 individuals. (In the fine meshed net in additio 5 cod.) 2 stations with a total of 8 hauls.

The appended tables contain more detailed in formation concerning the trawl catches at large Fig. 1 shows the distribution according to size of co and haddock in one haul, which are considered a non-marketable. Cod varying in size between 25 an 52 cm. are fairly evenly distributed. Haddock varie between 25 and 40 cm., the larger number measurin about 30 cm. Fig. 2 shows the size-distribution of co

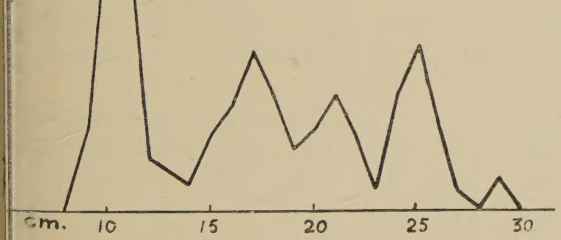


. 1. Size-distribution of 1236 specimens of small cod (full line) and haddock (broken line), caught in one haul at St. 86.

ught in the fine meshed net in one haul, the variation ing 8—30 cm. Fig. 3 shows the size-distribution of ddock caught in the fine meshed net in one haul, e specimens varying between 10—31 cm.

The survey given here shows a high percentage of n-marketable cod in the trawl catches on the örnöy Bank. This figure would possibly have become mewhat lower with a larger material from more uls. It would probably also have become consider-ly lower during fishing operations in other seasons th more copious supplies of fish at large.

In contrast to the catches on Björnöy Bank the ches from the Cape Kanin area show that, prac-ally speaking, the trawl here did not catch any n-marketable size of cod and haddock. However, uls previously made on the Shallow-Bank some-at north of these ("Michael Sars" 1907, D. Damas) August have given a great number of cod fry. us, it might be concluded that the smaller sized already had left this area and migrated westward ring the period of our investigations, as also the ger sized fish seem to do in the later part of the ter, when the ocean water on the small depths



ig. 2. Size-distribution of 191 specimens of cod, caught in fine meshed net at St. 52.

has cooled down considerably by the low temperatures of the air.

It would be of importance if similar investigations with trawl of normal size could be carried on in the Barentz Sea also during other seasons. However, I am of the opinion that the material collected on S/S "Borgenes" last winter gives a fairly correct impression of the amount of small fish which the trawl catches on the whole, and furnishes good reasons for apprehension as to the fish population in this area. It is a question whether this population can stand such excessive exploitation as this powerful depletion of fry of foodfish signifies.

While being employed for a couple of years as an active fisherman on board English trawlers in the North Sea, off the Faroes and Iceland, I have noticed that parts of the catch usually must be thrown overboard. During the last 32 years, when I have been

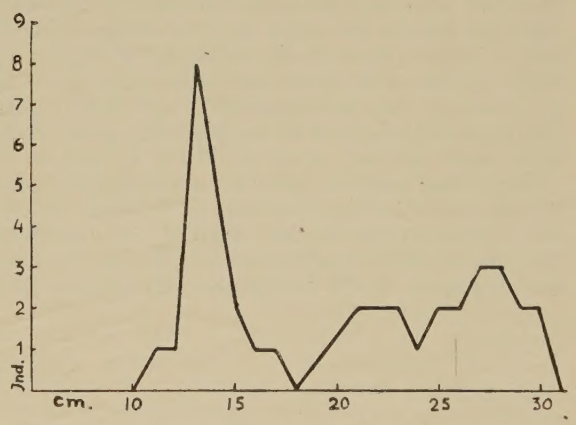


Fig. 3. Size-distribution of 140 specimens of haddock, caught in fine meshed net at St. 52.

associated with the Norwegian investigations of fisheries, I have had rich opportunity to manifest that the trawl as a fishing gear must destroy great numbers of small fish also in the Barentz Sea. I have gained this knowledge by fishing through a period of years with trawl of small dimensions on board the "Michael Sars". Reports of foreign trawlers in later years further confirm that destruction of the small fish occurs to a great extent. Previously, however, I have not had the opportunity of personally conducting fishing operations with trawl of normal size in the Barentz Sea and of undertaking more accurate investigations especially for this purpose. Of the investigations carried out through a period of years in different areas, I have gained the impression that the trawl-catches of non-marketable small fish in the Barentz Sea must be considerably larger than in any other area with which I am acquainted. Last winter on board the S/S "Borgenes" I asked myself: "Is it not possible to take measures which to some extent can check such great destruction of small sized fish?" I came to the conclusion that by establishing certain minimum mesh sizes in the trawl a step in the right

direction had been taken without thereby impairing to any great extent the trawling industry. At least, a fixed width of the mesh had possibly to be enforced during fishing operations with trawls in Barentz Sea and similar far off waters, where the great distances from the market cause the small sized fish to be without value and non-marketable on account of its poor keeping qualities. In this connection I especially have in mind the markets of the countries adjacent to the North Sea.

The part of the trawl where a fixed minimum size of the mesh is essentially needed is at the end of the trawl bag, the cod end. In this the fish are accumulated and insnared. It is tied of double twine and is exceedingly strong in order to be secure against bursting when hauled aboard with the catch. The cod end, which I have had the opportunity to examine on board the "Borgenes", was tied with 16 knots per 24 inches when new and waterproofed. A somewhat older cod end in use had 1 or 2 more knots per 24 inches, which proves some shrinking of the net by usage. On board the boat I procured some pieces of net made of new waterproofed twine and I found that mesh of the size of 14 knots per 24 inches would allow small haddock of about 30 cm. to escape.

These experiments of mine are not altogether satisfactory, and an ultimate choice of the mesh size, of course, has to be inquired further into by those interested and with co-operation of both manufacturers and employers of the fishing gear. My impression is that something would be gained by the introductio of a size of mesh in the cod end of 2—3 knots le per 24 inches than the one now generally used b the British trawlers.

The objection would possibly arise that the co end looses too much of its strength by the increas in size of the mesh, but I maintain that this migh be prevented by the use of correspondingly heavie twine.

My opinion is that a trawl with larger mesh in th cod end will not lose its catching power of large an marketable fish, on the contrary, it may possibly gai by this procedure, and accordingly I can hardl perceive that the fisherman of those nations whos most important fishing gear is the trawl should hav any justified objection to such a measure if this coul be introduced generally.

That the limitation of the size of mesh is a ste in the right direction appears correct, judging fro the experiments performed by attaching a piece c fine meshed net to the bag of the trawl. This ha not only been tried during the investigations of S/ "Borgenes" last winter but, in addition, several time on the cruises of "Michael Sars" during previous years

This moderate form of regulating the trawlin operations for the protection of the fry will be c benefit not only to the cod and haddock populatio but will also protect several other varieties of fish This will to some extent appear from the appende tables of catches.

Investigations on the Icelandic and Greenland Stock of Cod in 1932.

By

Å. Vedel Tåning, Copenhagen.

As is well known, cod fishing at Iceland has con-ntly increased during the later years, the inter-ional statistics showing the following total quanti-s of cod (in tons) from this area: 1913: 174,979, 0: 210,748, 1926: 301,194, 1930: 498,435.
The catches during 1931 and 1932 have been even ater than before for the Icelandic boats. The rease during these later years is undoubtedly due ne rich year class in particular, the 1922 year class. ystematic investigations with regard to the com-ition of the stock of cod in the area has only been ertaken since the present Committee was estab-ed on the instigation of the late Professor Johs. midt, i. e. about ten years ago. The results prior 1931 have been described in a publication of 1931 ctuations in the Stock of Cod in Icelandic Waters). experience of the last few years with regard to interchange of the stock of cod between Iceland Greenland as well as the drift of fry from Iceland East-Greenland has shown that the stock of these areas has to be treated from the same point of w. At Iceland the investigations have been con-ted partly by the Danish Committee and partly "Fiskifélag Íslands" through Árni Fridriksson, .; at Greenland, in the coastal area, through the enland Directorate" by Professor Ad. S. Jensen Paul M. Hansen, M.A., and on the banks by "Danish Commission" assisted by the fishery ection ships and Faroese cutters.
he investigations are mainly based on measure-ts and age-analysis by means of otoliths; owing ack of statistics, the extremely varying fishing hods etc. it has hitherto been impossible to form dea of the absolute quantitative representation he various year classes of cod in the sea, the investigations carried out give, therefore, no more than an indication of the proportional strength of the year classes.

The otolith method has been exclusively used, as scales of cod, at the age here treated, seem practically useless in these waters. To obtain a uniform treatment of the material during the winter months a determination af the same otolith samples from the spawning area at South Iceland was undertaken twice on the instigation of Professor Schmidt, by four persons who are dealing with these cod analyses (Messrs. Árni Fridriksson, Paul M. Hansen, A. Bruun and Vedel Tåning) independently of each other. A comparison of these determinations showed that one of the investigators had considered the summer ring nearest to the edge on a large part of the otoliths as a secondary ring, while all the other investigators considered this ring as a primary one and generally speaking they were very much in agreement with each other, 40—60 % of the determinations from these three investigators were absolutely in accordance with each other. It was discovered that by making thin sections of the otoliths with the help of grinding machines, constructed for mineralogical purposes, preparations were produced which were of the greatest value for the determination of the edge zone in otoliths of older cod. As the making of these sections by means of suitable machinery only takes very little time (about 10 minutes per section) it is evident that this method can be used with regard to the determination of otoliths of the older year classes of cod to obtain results as accurately as possible.

enland (1932).

oastal waters (from Paul M. Hansen[1]).

-class	1928	1927	1926	1925	1924	1923	1922	1921	1920	1919	1918	1917	1916	1915	1914	1913	1912
....	0.9	1.6	**11.7**	1.7	**50.8**	1.1	**18.4**	0.6	0.6	1.2	0.2	**10.5**	0.2	0.7	0.03	0	0.6

fshore banks.

class	1929	1928	1927	1926	1925	1924	1923	1922	1921	1920	1919	1918	1917	1916	1915
.. ..	0.2	0.9	5.2	**22.1**	0.3	**15.7**	7.3	**31.3**	2.9	2.8	3.5	0.3	**6.9**	0.3	0.3

nd (spawning grounds) (1932).

class	1927	1926	1925	1924	1923	1922	1921	1920	1919	1918	1917	1916	1915	1914	1913	1912
....	0.9	1.1	3.1	**16.9**	6.3	**59.4**	5.1	0.9	3.7	0	0.6	0	0.3	0	0	0.3
930)				(0.4)	(7.8)	(60.7)	(8.0)	(6.0)	(10.4)	(2.0)	(1.8)	(0.9)	(1.1)		(0.9)	

[1]) Investigations in East-Greenland waters show that the dominant year classes here are 1922, 1924 and 1926, i. e. as in West-Greenland.

The investigations during the later years show that the year classes 1919, 1922 and 1924 are predominating in the Icelandic area; with regard to the Greenland area it has been the year classes 1917, 1922, 1924 and 1926 which have been predominating.

The material of 1932 from the area shows the percentage of age composition as given below. About 20,000 measurements have been collected and 3—4000 age analyses of otoliths undertaken. It appears that also in 1932 the above mentioned year classes are the predominating. With regard to Greenland a distinction has been made between the coastal area and the offshore banks, while for Iceland an analysis of a sample from the spawning area is given.

The 1922 year class is still absolutely predominating at Iceland, this year class appeared for the first time 8 years old and in great number (60 %) on the spawning grounds in 1930; the year class 1924 — which particularly at East Iceland has been noticeable since 1925 as a rather strong year class — has appeared now, 8 years old, on the spawning grounds. During 1931—32 the strength of the year class 1922 has been reduced considerably at West Greenland in most of the localities of the coastal area to the benefit of the 1924 year class, in 1929 the stock implied more than 60 % of the year class 1922. This reduction in strength of the 1922 year class is in perfect accordance with the strong emigration in 1930—32 to Iceland, shown through the marking experiments, and which according to the age analysis mainly comprises specimens of the 1922 year class. A good year class decreases considerably at an age of some 14—15 years in these waters but seems to be traceable up to 20 years of age. With regard to the Icelandic area there is, according to the present composition of stock, prospect of some more years fishing ab normal.

Measurements in the above mentioned area much more difficult and more uncertain to use t in the Norwegian area, where Mr. Oscar Sund developed the study of measurement curves to a gr perfection. Taking for instance the Icelandic area has appeared that the average length of the 1 year class on the spawning grounds at South Icel is practically unchanged from 1930 to 1932 which been caused by a strong immigration of sma specimens of the year class from the cold north and eastern coast of Iceland and other places wh the growth of the younger stationary year clas may lie some 10—20 cm. below the growth at warmer southern and western coast.

Investigations into the stock of cod at Greenla Iceland and Norway during the last few years h shown that a number of year classes in this large a have been especially good. This seems to be the c with the year classes 1912, 1915, 1917, 1919, 19 and 1924, but at the same time one of these str year classes may be weak in some particular area for instance the 1919 year class at Greenland. T domination of about six year classes through a num of years as well as the deviations from this v noticeable uniformity may probably, through stu and comparison, during several years, of import hydrographical and other factors in the whole ar furnish the key to a true indication of one or m factors which are determining whether a year cl becomes particularly strong or particularly poor the respective areas.

Recent Observations on spent Herrings and Remarks on Forecasting.

By

G. Gilson, Ostend.

n interesting shoal of herrings accumulates every
between the middle of December and the
days of March, along the continental coast,
veen Cape Gris-Nez and the mouth of the Schelde.
y are nearly all "spent" at Hjort's stage VIII
. In 1930—31, 97.51 % were at that stage and
at all were "full". Although spent herrings are
nferior commercial value an important fishing on
Belgian coast is due to this appearance. In 1931,
quantity landed at Ostend amounted to more
18 million kg. sold by auction for the sum of
16,891 fr. This successful fishing amounted to
than 217 mill. individuals caught. The average
ht of one fishing was 8,338 kg. (ships of all sizes
ded).

e have been following, without interruptions, the
successive fishing seasons 1930—31, 1931—32
1932—33, and found that whilst the first was
rkably rich the two latter were among the
st ever recorded.

Spent Herrings — Ostend.

eason	Quantity in kg.	Number of individuals	Average weight of one fishing
—28....	3,857,383	44,745,643	4,739
—29....	12,121,953	140,614,655	11,545
—30....	11,282,163	130,873,091	7,302
—31....	18,360,596	217,002,545	8,338
—32....	3,353,455	34,976,536	5,435
—33....	2,673,185	29,405,035	4,515

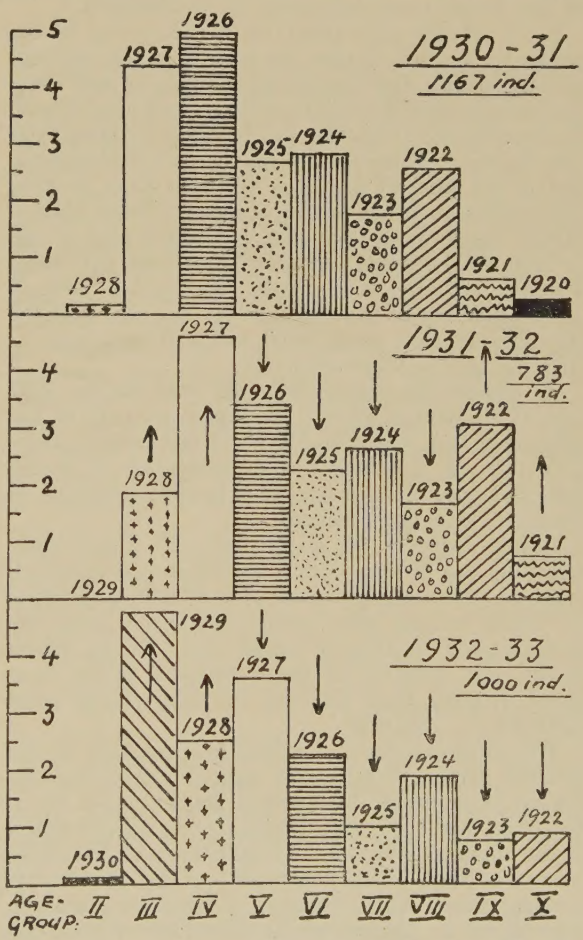
e results of these daily observations, during the
easons, lead us to some remarks on forecasting
hery matters, which I shall try to expose very
y.

e forecasts that one may attempt to formulate
e case of a local herring fishery are three kinds:
recast of the relative proportion of each
the year classes for the next season; this may
called qualitative forecasting.
recast of the abundance or density of the
al that is expected to concentrate in the region
the course of the next season.
recast of the abundance of the same con-
tration which is expected to return three years
r the season considered. The last two may be
ed quantitative forecasting.

us take an instance of each of the three kinds
ecasts out of the diagram called "Biological
of spent herring.

h of the three steps of this scale corresponds
yearly season; the columns are the percentage
viduals in each class, that is the proportion of
lass in a hundred herrings supposed to have
been caught at random from the shoal. Six classes have played an important part in the concentration of the season 1930—31; they are the classes born in the years 1922 to 1927. Herrings 3 and 4 years old were enormously predominating, whilst a good proportion of older herrings was still present, one column only being rather poor: that of the 1923 class which has always been a notoriously bad class all over the Southern North Sea, as clearly shown in several memoirs by Jean le Gall.

1. — Based on the figures of this diagram we have predicted that the diagram of the next season would also show an important percentage of young herrings one year older, i.e. 4 and 5 years old respectively,



	1930—31	1931—32	1932—33
Total value, francs ..	13,008,930	3,642,806	2,446,867
per 100 kg, — ..	71	108	91

for further details: see Table.

and a moderately high percentage of older fish (6 to 9 years).

The second step of the scale 1931—32 shows that the forecast was successful. It shows also that a new group of three years old herring appears in one shoal with a fairly good proportion. From this second step of the diagram we could also foresee that the third season would still have a good, although reduced, proportion of young herring 5 and 6 years of age and a decreasing percentage of the older classes.

In fact, we find in the season 1932—33 a still good percentage of the two classes 1927 and 1926, that were predominating in the two previous seasons, and all the older classes, on the right, greatly diminished. A peculiar feature that could not have been foreseen has appeared in the composition of the shoal: the unusual importance of the new class of 3 years old herring: 24 %. The column of 4 years has also increased notably. The decrease of the six older classes is partly a consequence of the increase of the percentage of the young ones (balancing of percentages).

2. — About quantitative forecasting let us remember first of all that the figures, in the material we are dealing with, are all percentages and these percentages cannot forecast anything but percentages. No quantitative prediction can be directly drawn from our diagrams. However, we may obtain probabilities out of this kind of diagrams when we have positive information about the history of certain classes. If some of the classes have played an important part in one or more good seasons passed, we may infer that there has been, actually, an important number of individuals of those classes at that time in the sea, and that the survivors of that great shoal will still be numerous during the next season.

As regards the season 1931—32: two classes, 1927 and 1926, having played an important part in the extremely rich season of 1930—31, we could reasonably forecast, not only a high percentage of young fish, but also a considerable, absolute quantity of herring and a good fishing.

In fact, however, the season 1931—32, immediately following one of the richest concentrations on record, was an extremely poor one. The relative proportion of young herring was certainly in accord with the forecast; but the average weight of one fishing, which is the only criterion of the abundance of fish in a shoal, dropped from 8,338 kg., in 1930—31, to some 5,000 kg. in 1931—32.

This is undoubtedly a remarkable instance of the possible perturbations in the normal course of a biological phenomenon. Its causes are unknown to us but some may easily be guessed at: one may be found in the magnitude of the transgression of Atlantic water of high salinity pointed out by the British hydrographers. The encounter of repulsive plankton, *Phaeocystis* or others, might also have turned the herring from their usual way back to the breeding grounds.

Another possible cause of the poverty of the concentration of 1931—32 may have been the intense fishing of 1930—31. The destruction of more th 217 mill. individuals may have heavily affected community of herring which appears to be a relative small one, never equal in size to the immense sho of Northern North Sea. It seems possible that t concentration of 1930—31, although an extremely ri one, was too heavily taxed by the excessive destructi in that fishing season.

3. — The second kind of quantitative forecasti is that of the abundance of herring in the third ye after a season just finished. This seems to be som what safer than the predictions for the immediate following season, especially when the two intermedia seasons are also known and analysed. The reason that the first generation to appear as a notable eleme of a returning shoal, is the class of three-year o herring, so that a given class is always largely depe dent on the conditions of breeding in the season thr years before.

Forecasts for the Season 1933—1934.

Although feeling very little inclination towar making predictions, I consider it expedient to c attention to certain signs that seem to forecast abundance of young spent herrings in the next seas along our coast.

The main consideration for this forecast is that t next season will be the third after the excellent co centration of 1930—31. We may safely admit th the extremely numerous, spent, herring of that ri season had given birth, previously to their comi to our coast, to an immense number of larv These are likely to come back as young mature herrin to breed in their turn and to accumulate afterwar for several weeks along our coast as spent herrings

We may also consider in the diagrams the t intervening seasons 1931—32 and 1932—33, when t young classes, 1928 and 1929, were very well rep sented by percentage in their first appearance, whi is always a promising feature.

Reservations.

It must, though, be kept in mind that hitches always possible and that no prediction is infallib Although the number of progenitors, and consequen the number of eggs, was enormous in the seas 1930—31 we cannot be certain that the breedi has been a success. As long as quantitative data not obtained about the larvae in the Straits of Do and in the South of the Southern Bight there is ro for doubt about the success of fecundation a hatching. Another uncertainty looms over the act thriving of the larvae after the frail creatures ha been carried away by the currents. Salinity, tempe ture, plankton and currents may have been unfavo able, both at the time of hatching and afterwar and mortality may have been very great.

Let us remember also that coastal concentratic in a narrow passage of the sea are subject to gr

gularities resulting from different causes, among ich may be mentioned the intensity and variability tidal currents in the Straits, the variable mixing ich they cause between the different masses of ter, of plankton, of larvae and even of adult herring onging to the two varieties neighbouring in the ndary area. Conditions more favourable to fore- ts are prevailing in open seas like the East Anglian ion or the broad part of the Channel.

However, perturbations, like the above mentioned, of what may be considered to be the normal course of annual displacements are possible everywhere. They show the necessity of continuous hydrographical observations and they teach us, objectively, how cautious we must be when we decide to turn prophets, if sincerely we wish to guide the fisherman to success and not to run the risk of leading him dangerously astray.

Herring Larvae.

The Mixing of the Broods in Scottish Waters.

By

Robert S. Clark, Aberdeen.

he frequencies of occurrence of the herring larvae in the collections made by the Scottish Research sels throughout the period 1904 to 1932 are shown Table 1 where the grouping is arranged according ize categories of 5 mm. increment. The material sists mainly of the smaller sizes of larvae, 94 % g less than 26 mm. and 89 % less than 21 mm. ength. The numbers in the size group 6—10 mm. titute about half the total number of larvae, e those exceeding 25 mm. in length represent only of the captures. The proportion greater than m. is less than 1 % so that it would appear the types of nets used in these investigations not very efficient for the capture of the larger, active stages. The table shows a regular decrease e larvae from the smallest to the largest within 5 mm. grouping. This regular decrease in the uencies of occurrence of the larvae is undoubtedly to mortality among the larvae and to their dis- l over a wider area with increasing size.

e amount of sampling carried out and the areas ined each month were very uneven. The numbers rvae caught monthly, therefore, do not accurately sent the absolute abundance of larvae at various ns of the year. Table 2, which gives the total ber of larvae caught each month is, however, ictive. There are five outstanding months for ccurrence of larvae, namely, March, April, May, n-ber and October. Fifty per cent. of the material aptured in the last two months and the larvae sufficiently numerous in the collections in the months of March, April and May to comprise about 41 % of the total larvae caught. In collections made in the other months of the year the numbers of larvae caught were insignificant except in June and November, when each month was represented by 3 %. The small number of larvae caught in the winter months is partially accounted for by the fact that the investigations were curtailed considerably at that period of the year, but this explanation cannot be used to account for the paucity of larvae in the collections during the month of July when the investigations were carried out over a wide area with increased intensity. Obviously the very small larvae which are so easily caught in numbers by the plankton nets were not present to any appreciable extent, while the larger larvae, if present in the area, were either extremely few in number or too large and active to be taken by the nets during these months. On the other hand, the fact that 89 % (vide Table 1) of the total larvae caught were under 21 mm. in length suggests that the high frequencies in March, April, May, September and October are due to the presence of the newly-hatched or small larvae.

The relative abundance of the larvae in each of the months is illustrated in Table 3 which gives the total larvae captured and the frequencies per 1000 larvae at each size group. In the four months March, April, September and October when large numbers of larvae were captured, the percentages of larvae under 11 mm. in length in the catches are high. In other words there were larger numbers of larvae

Table 1.

Herring Larvae, 1904—1932. Frequencies of Occurrence in Size Categories of 5 mm. increment.

roups...	6—10	11—15	16—20	21—25	26—30	31—35	36—40	41—45	46—50	51—55	56—60	Total
iencies..	229990	152240	80575	25396	5385	2812	6683	6183	5750	2674	1819	519417
currence	44.2	29.3	15.5	4.8	1.0	0.5	1.2	1.1	1.1	0.5	0.3	

recently hatched out in the collections during these months. It will be noted, however, that small larvae were also relatively numerous in the collections during August and from a consideration of larvae less than 11 mm. in length, vide column 1 of Table 3, the extent of the hatching periods in Scottish waters may be determined approximately. No hatching takes place in January but before the end of February a few newly-hatched larvae begin to appear in the plankton collections. Hatching is intensive in March and continues throughout April and into May. Before the end of May, hatching, except at the Faroes, has ceased and no more newly-hatched larvae are captured before the end of July. They do not appear in numbers, however, until August and the maximum is reached in September. Thereafter, newly-hatched larvae become relatively less numerous in the collections until they disappear for the season in November. By December, the larvae which had hatched out in the earlier months have grown and the majority now exceeds 10 mm. in length. The table thus brings out very clearly the fact, already well known, that there are two spawning seasons for the herring in Scottish waters, namely, spring and autumn. The autumn brood begins to emerge from the demersal eggs in July and before the end of August some of the larvae have grown to a size of 21 mm. While spawning may continue until at least the end of October, some of the earlier hatched and quickly growing larvae may reach 30 mm. by the end of September, 40 mm. by the end of October and a few may even exceed 45 mm. in length by the end of the year. In the month of December, however, large numbers of larvae of the autumn brood are still less than 30 mm. in length and such small larvae are found to be present in the plankton collections in January and February before the spring brood begins to appear. Thus it is obvious from the collections that most of the larvae of the autumn brood are carried over the winter period while still in the larval condition. In the month of April, 88 % of the larvae caught were less than 16 mm. in length, so that the earlier hatched individuals of the spring brood still remained small. A relatively small number of larvae of the previous autumn brood, however, was caught even as late as June. From a consideration of the size frequencies of the larvae occurring in the plankton collections in May, it is evident that the numbers of the spring brood have grown considerably since the previous month and some may even exceed 25 mm. in length. Growth continues to be rapid and by the end of June most of the spring brood are greater than 15 mm. in length. The better grown larvae are difficult to capture and in view of the fact that the larvae of the previous autumn brood have also grown considerably, fewer larvae are caught by the nets and in July herring larvae are practically unrepresented in the plankton collections.

In the shallow inshore areas, however, the larger larvae have been taken in considerable numbers especially in enclosed areas, by small meshed bottom nets, chiefly shore seines, boom nets and trawls. This is particularly noticeable in the figures for June and

Table 2.

Herring Larvae, 1904—1932. Monthly Totals, Percentages and Mean Sizes.

		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	De
Total		967	887	35286	100785	75803	15826	1796	6554	167443	92439	15558	607
%		0.2	0.2	6.8	19.2	14.6	3.0	0.3	1.3	32.2	17.8	3.0	1.
Mean Size in mm.	Spring	—	8	8	11	17	38	50		Scaled			
	Autumn							8	10	10	13	17	2
	do.	25	26	33	39	42	52	68		Scaled			

Table 3.

Herring Larvae, 1904—1932. Frequencies in 5 mm. Size Groups per 1000 larvae.

Months	6—10	11—15	16—20	21—25	26—30	31—35	36—40	41—45	46—50	51—55	56—
January	—	8	191	362	214	142	73	8	1	—	—
February	1	5	114	360	286	136	55	41	2	—	—
March	932	37	2	4	7	9	7	2	+	—	—
April	440	447	48	3	2	6	32	22	1	+	—
May	10	373	484	109	7	1	3	11	2	+	—
June	—	+	17	49	13	29	161	182	334	133	81
July	1	—	1	13	112	80	37	39	124	302	291
August	666	294	37	2	—	—	—	+	+	1	—
September	655	262	72	10	+	+	—	—	—	—	—
October	403	270	212	96	17	2	+	—	—	—	—
November	33	422	319	145	54	18	5	3	+	+	1
December	1	47	250	402	185	79	28	6	+	—	—

N.B. + indicates larvae present but proportion less than 1 per 1000.

ly months, vide Table 3, where the numerical value the size groups increases with the larger sizes as posed to the regular decrease from the smallest to e largest sizes in the plankton collections. Further nsideration of these larger sizes may be made from ble 4. During May, the size categories show two xima. In June and July these maxima are masked the apparent rapid growth of both broods, though re is a distinct break in the Shetland June samples. is practically impossible to separate the broods by e frequencies alone and the apparent mixing and erlapping of the broods in June and July has had be cleared up, partially at least, by a study of the rphological features of the individual larvae. The an sizes of the two broods of larvae are arranged nthly on Table 2. The spring brood shows a gradual rease from February to April but from May wards there is a distinct jump in growth, so that July the majority of the larvae is in the scaled ge. The autumn brood shows a more gradual pro- ssion towards the winter months when growth ws down but the same spurt in growth takes place the spring months and the scaled condition is ched in early summer. It must be understood, wever, that the calculations are based on the reme limits of the smaller larvae caught by the nkton nets and on the lower limits of the larger better grown larvae taken by the bottom nets. e prolongation of the hatching periods will also d to lower the mean sizes of the smaller and medium d larvae so that the figures must be taken broadly, ecially as they are calculated from the captures for the whole of the Scottish area, within which there may be considerable divergence in growth rate. Evidence of the overlapping of the broods can be seen from the size frequencies of the captures of transition stages at Aberdeen during June and July as recorded on Table 5 and from the accompanying graphs of the percentages of the total number of vertebrae. In other words the better grown larvae of the spring brood catch up on the slower growing larvae of autumn incidence.

The origin points of the larvae have been defined primarily in time and place by the captures of the newly-hatched larvae. The localities of incidence, however, are widely scattered over an extensive area and it is not always possible in any one year to cover the whole ground with a single research ship and to catch the waves of hatching at the right time. Representation of the various localities, however, has been obtained over a series of years. Confirmation of the hatching places has been ascertained from the records of "spawny haddocks" and these have been plotted on the accompanying charts. An approximation to the hatching centres has also been possible from the captures of very small larvae less than 11 mm. in length which would not have been far removed from their positions of incidence. The outer limits of occurrence of these larvae have been indicated on the charts and it is obvious that these bear a definite relation to the positions of capture of spawny haddocks and of the newly-hatched stages. The dispersal of the larvae from the various hatching centres has been indicated broadly by the outer limits of occurrence of all

Table 4.

Herring Larvae. Total Records in Divisions of the Area for May, June, July.

th	Locality	Frequencies in 5 mm. Size Groups												
		6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70
	North of Scotland	16	1588	1588	3627	406	8	—	—	—	—	—	—	—
	East Orkneys—													
	Shetlands.....	5	74	74	137	13	1	—	—	—	—	—	—	—
	Moray Firth....	6	17	17	61	10	3	44	4	—	—	—	—	—
	Aberdeen.....	—	—	—	1	—	—	27	20	1	—	—	—	—
	Firth of Forth..	473	13780	27263	3185	3	39	169	828	123	3	—	—	—
	Total...	500	15459	29844	7011	432	51	240	852	124	3	—	—	—
e	North of Scotland	—	2	224	440	55	—	—	—	—	—	—	—	—
	East Orkneys—													
	Shetlands.....	—	—	11	129	51	10	—	35	327	366	125	49	13
	Moray Firth....	—	—	14	100	85	79	39	4	—	1	—	5	2
	Aberdeen.....	—	—	—	6	21	532	2608	2859	4961	1740	1154	471	151
	Firth of Forth..	—	—	2	8	21	3	—	—	—	—	—	—	—
	Total...	—	2	251	683	233	624	2647	2898	5288	2107	1279	525	166
	North of Scotland	—	—	—	—	—	—	—	—	—	—	—	—	—
	East Orkneys—													
	Shetlands.....	—	—	—	—	—	—	1	—	—	—	—	—	—
	Moray Firth....	—	—	—	—	—	—	—	—	—	—	—	—	—
	Aberdeen.....	—	—	—	1	3	4	13	52	165	520	504	296	92
	Firth of Forth..	—	—	1	23	199	142	49	2	1	1	3	2	—
	Total...	—	—	1	24	202	146	63	54	166	521	507	298	92

the unscaled stages. It is thus possible, within limits, to correlate the larvae at various stages of development with their localities of origin though it becomes increasingly difficult in the case of the larger sizes, some of which may have been transferred considerable distances from their localities of origin.

Hatching of the spring herring as indicated in the accompanying chart is not continuous round the Scottish coasts but occurs at certain definite localities within the continental plateau at depths ranging from a few fathoms to close on the 100-fathom line. The majority of these hatching centres occurs within a depth of 50 fathoms but there are incidences of some importance outwith this depth from west of the Hebrides to north of the Shetlands and between the Shetlands and the Norwegian Deep. It has not been possible to compare the actual productivities of the various hatching centres, largely on account of the irregularity of the sampling but an attempt has been made in the following table to give a general idea of the conditions prevailing within the area from the percentage frequencies of occurrence of the small larvae 6—10 mm. in length over the hatching period March to May, and from the number of visits of the Research Vessel to each area.

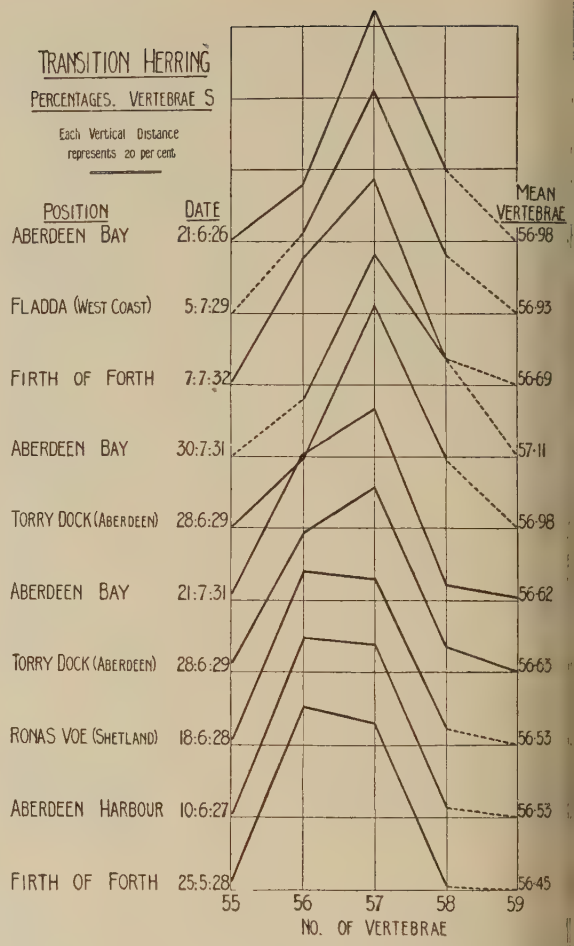
Spring Larvae.

Total Records 6—10 mm. over hatching period.

Percentage Frequencies fortnightly.

Area	March 1	March 2	April 1	April 2	May 1	May 2	No. of larvae per 10 visits
Clyde.....	—	—	6	94	—	—	127
West Coast	—	—	—	100	—	—	227
N.W. Hebrides & West Minch...	+	—	73	19	7	—	1947
N. Scotland & East Minch ...	—	3	96	—	+	—	5965
N.W. Shetlands..	1	8	4	86	—	—	479
S. Shetlands.....	—	—	—	—	+	—	1
Deep Water Northern North Sea.....	—	—	+	+	—	—	2
Norwegian Coast.	—	—	100	—	—	—	403
East Orkneys & Moray Firth ..	—	+	+	+	+	—	2
Firth of Forth ..	+	83	14	2	1	+	3804

The table is not quite satisfactory on account of weak sampling along the west coast of Scotland, in the region of Viking Bank and along the Norwegian coast. The poor representation of the Shetland area especially to the north-west of the islands may, however, be explained by the difficulty in catching the hatching waves at the right time on account of the greater depth of water and the speed of dispersal of the larvae in this region. The paucity in numbers of larvae from the East Orkneys and the Moray Firth is probably accurate as sampling took place at these



localities on a large scale. No small larvae were take along the East Coast of Scotland between the Mora Firth and the Forth, but an odd record of "Spawn Haddocks" indicates that spawning may take pla on a small scale in this area in certain years. The tab brings out clearly the uniformity in time of occurren of these small larvae in the various divisions of th area and this is emphasised by the monthly appea ances of the newly-hatched larvae as indicated o the chart. There is apparently little hatching duri the first fortnight in March and none during th second half of May, while the major hatching seen to occur during the second fortnight in March an throughout April.

Major spawning centres are indicated at the Firt of Forth, along the north of Scotland and west an north-west of the Shetlands, but the region of th Viking Bank, though of considerable importance, probably given too much prominence on the cha The locality south of the Shetlands which gave po tive records of spawning in at least two post-war yea has not been substantiated as an annual spawni area of much importance. The general dispersal rout of the larvae are indicated by the outer limits

Table 5.

Transition Herring. Samples examined for Vertebrae S. and completion of Keeled Scales.

Locality	Date	Frequencies in 5 mm. Size Groups												Number Examined	Range in Sizes Examined	K_1 compl. at size	K_2 compl. at size	Mean Vertebr. S.
		21—25	26—30	31—35	36—40	41—45	46—50	51—55	56—60	61—65	66—70	71—75	76—80					
berdeen Bay	31:7:31	—	—	—	1	31	183	520	504	296	92	35	28	262	41—65	45	53	57.11
	21:7:31	—	—	—	—	—	—	—	—	23	121	117	57	75	67—85	—	—	56.57
berdeen Bay	21:6:26	—	9	439	2509	2648	275	5	1	—	—	—	—	564	31—55	48	ca.60	57.02
adda.....	5:7:29	—	—	—	11	83	141	120	58	17	1	—	1	269	36—65	43	53	56.93
rth of Forth	7:7:32	10	101	72	26	1	—	—	—	—	—	—	—	146	25—40	40	—	56.69
berdeen Harbour ..	28:6:29	—	—	1	23	159	314	531	433	303	120	34	5	806 305 501	38—70 38—50 51—70	49	62	56.77 56.98 56.63
etlands Ronas Voe)	18:6:28	—	—	—	—	35	327	366	125	49	13	2	—	533	44—55	46	60	56.53
berdeen Harbour ..	10:6:27	—	—	1	21	41	4366	1204	720	168	31	—	—	294	46—55	45	60	56.53
rth of Forth	25:5:28	—	—	1	3	240	85	3	—	—	—	—	—	224	40—53	46	—	56.45

urrence of all the unscaled larvae. On the west i north-west coasts, the larvae tend to keep within just beyond the contour line of 100 fathoms and be strewn along the Continental Plateau from south north and towards the northern gateways to the rth Sea and outwith the North Sea towards the rwegian Sea. Within the North Sea, larvae were en in the deeper area north of the 59th parallel west of the prime meridian but were absent from hauls in the central area. They were present along Scottish coast but the southern captures were inctly localised in close proximity to the Firth of th. During one year only, in May 1931, small to lium sized larvae were got at the Faroes and in neighbourhood of Faroe Bank.

he distribution of the autumn hatching centres ws quite a different arrangement from that of the ng. Little or no spawning takes place in autumn ond a depth of 50 fathoms and the majority lies within this limit. During recent years investiga- s along the west coast of Scotland have not lted in the capture of the smallest sizes of larvae e the numbers of larger larvae have been nificant. Newly-hatched stages, however, have been n throughout the north and east coasts. The outer ts of distribution of larvae 6—10 mm. in length ring in August are also indicated on the chart it will be seen that they are confined to the hern area, north of Buchanness. From a con- ation of the times of occurrence of the newly- hed larvae and from the percentage frequencies ightly within the various sub-divisions of the as shown in the following table it is concluded the main hatching of the autumn larvae is pro- ively later from north to south within the North

Autumn Larvae.

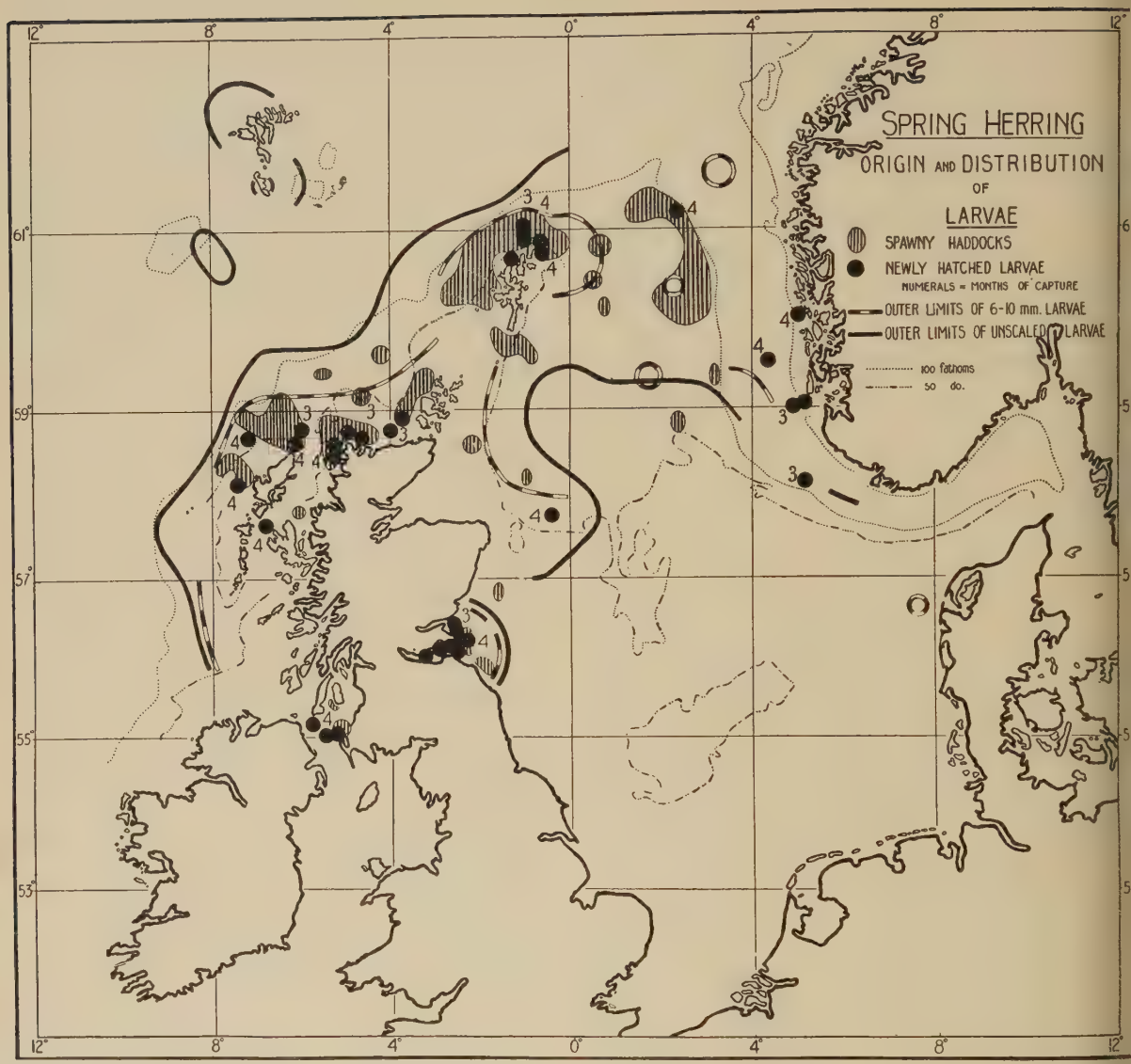
Total Records 6—10 mm. over hatching period.

Percentage Frequencies fortnightly.

Area	Aug. 1	Aug. 2	Sept. 1	Sept. 2	Oct. 1	Oct. 2	Nov. 1	Nov. 2	No. of larvae per 10 visits
Clyde.....	—	—	—						- -
West Coast	—	—	—	—					—
N.W. Hebrides & West Minch...	—	—	—	+	—	+	—		+
N. Scotland & East Minch ...	1	27	55	16	—		1		72
Shetlands & Foula Bank.....	5	69	12	13	—	—	—	—	2
E. Orkneys & Fair Isle	+	60	31	4	4	+	+	+	74
Moray Firth	+	1	9	89	2	+	+	+	456
East Coast.....	—	+	46	17	36	+	+	—	433
Longstone & Dogger	—	—	1		97	+	2	—	135

The table also brings out clearly the relative importance of the various hatching centres, though the weak representation of the Shetland area is perplexing and requires further investigation.

The outer limits of the unscaled larvae are shown separately for the periods up to the end of December and during the spring months. It is obvious that the trend of the larvae to the north of Scotland is in a north-easterly direction. Within the North Sea, the larvae at least up to the end of November spread out towards the middle of the deeper northern area and push out in an easterly direction towards Ling Bank and the Great Fisher Bank. They are also carried southwards along the coast and south-eastwards through



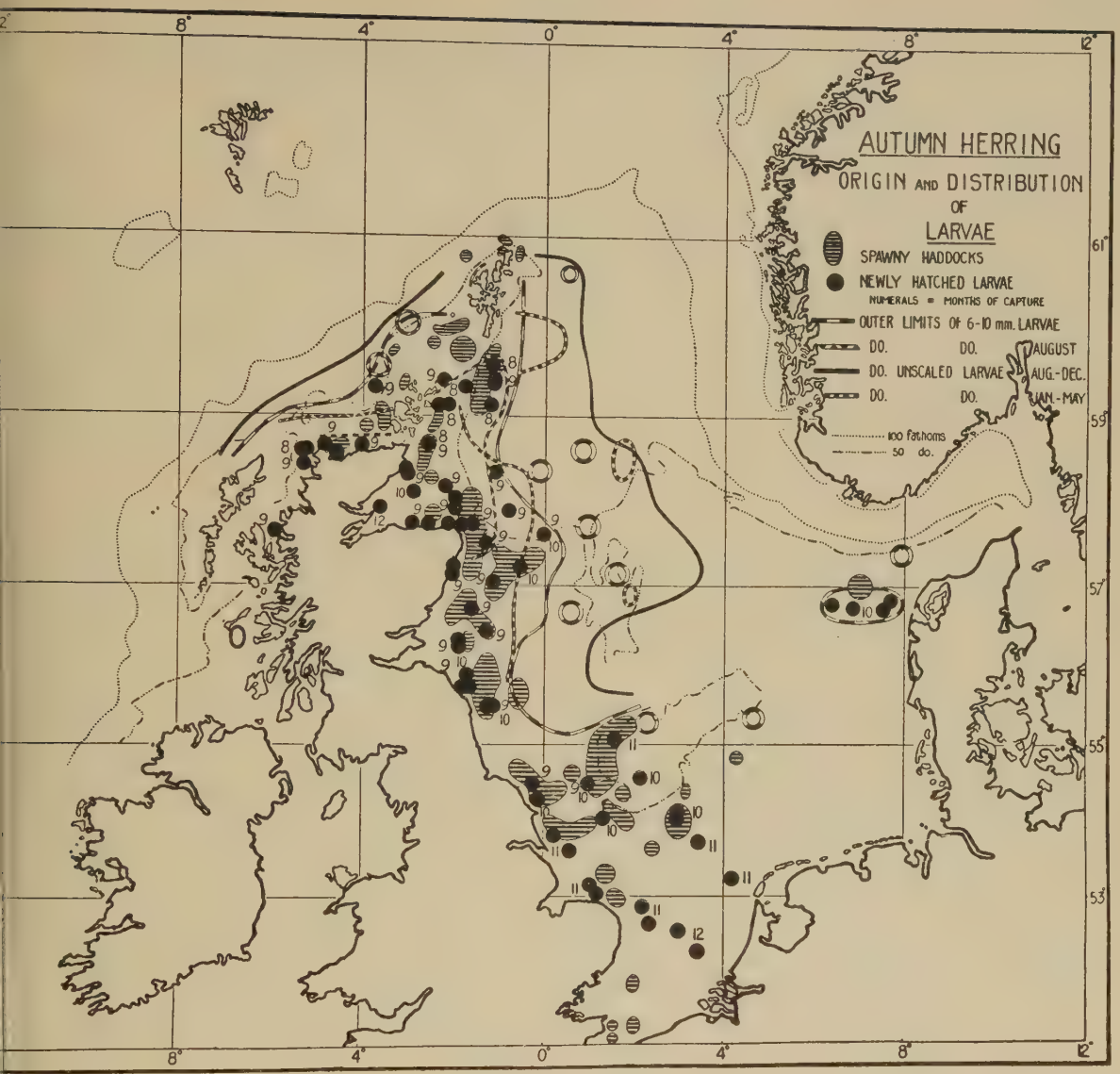
the Gut but no larvae of autumn origin have so far been recorded between the Gut and the north-eastern part of the Dogger Bank. During the period January to May, the distribution of the larger larvae is more restricted and captures have been made in close proximity to the coast.

The capture of the larger transition stages has not by any means been an easy proposition and there is still some doubt as to the localities where the great concentrations occur. They have been taken in the bays and estuaries throughout the Scottish coasts at varying sizes during most months of the year but have not been captured in offshore waters except in insignificant numbers, though diligent search has been made for them.

Table 6 illustrates the monthly composition of catches obtained by nets which capture unscaled transition and the smallest scaled stages. The larger scaled stages, however, are not dealt with in the present communication but these have been caught in large numbers by trawl, seine and boom nets in various inshore areas. The mixing of the broods is still apparent as shown by the following table of captures during the last two months of the year in the Firth of Forth area.

cm. groups ...	5	6	7	8	9	10
Frequencies..	31	386	878	2107	3187	252

cm. groups ...	11	12	13	14	15
Frequencies..	1596	1073	715	773	1357



he spring brood which has already been noted in (vide Table 6) has now attained a modal size oximately of 9 cm. The mixing with the previous mn brood is also evident from the rise in the encies at 14 cm. and over.

e winter carry over of the autumn larvae is in nce from January to May (vide Table 6) but ne and July the better grown of the spring e have caught up on the slower growing larvae tumn incidence and there is in consequence over- ng of the broods. From August to October the es have consisted of fish hatched in the spring e year but the larger sizes — still unscaled — of utumn series of the same year seem in November approaching in size the smallest scaled spring These autumn larvae, however, are still in the elongated larval condition, have not undergone reduction in size, and are apparently a long way off metamorphosis.

The mixing of the broods, therefore, must be sought for in the summer months and representative samples from various localities have been examined morphologically with a view to separating the broods, vide Table 5 and the accompanying graphs. From the mean number of vertebrae it is evident that the samples comprise two groups, one with a low the other with a high number of vertebrae. The sample from Aberdeen Bay ($^{21}/_{6}$ 26) is probably homogeneous. The mean number of vertebrae in samples from the size groups 31—40 mm. and 41—55 mm. has been examined separately and the mean has remained high in each case, being 57.03 and 57.04 respectively. The

Table 6.

Transition Stages caught by Small Meshed Nets. 1925—1933.

Month	Frequencies in 5 mm. Size Groups											Brood
	16—20	21—25	26—30	31—35	36—40	41—45	46—50	51—55	56—60	61—65	66—70	
January.....	9	34	22	38	50	6	1	—	—	—	—	Autum
	—	—	—	—	—	—	—	—	12	—	32	Spring
February.....	—	—	—	8	36	35	2	—	—	—	—	Autum
March	5	40	117	416	513	98	2	—	—	—	—	Autum
April	—	12	130	636	3262	2240	121	6	—	—	—	Autum
May.....	—	—	2	29	156	819	146	5	—	—	—	Autum
June.....	—	—	52	599	2624	2822	595	182	1	—	—	Spring
	—	—	—	1	21	76	4694	1924	1283	686	41	Autum
July.....	1	24	200	144	103	169	365	662	577	297	5	Spring
	—	—	—	—	—	—	—	1	3	58	213	Autum
August.....	—	—	—	—	—	40	38	9	5	3	4	Spring
September.....	—	—	—	—	—	—	—	—	1	2	—	Spring
October.....	—	—	—	—	—	—	7	—	163	—	—	Spring
November.....	—	—	—	12	24	36	—	—	—	—	—	Autum
	—	—	—	—	—	—	10	23	63	99	147	Spring

Fladda sample ($^{5}/_{7}$ 29) shows exactly the same type of graph with a high peak at 57 and a percentage between 10 and 20 for 56 and over 20 for 58 vertebrae. These samples therefore must both be composed of spring fish and the Aberdeen sample must have originated from a northern spawning area either to the north of Scotland or at the Shetlands.

The Firth of Forth sample ($^{7}/_{7}$ 32) shows slightly different characteristics from the above. The percentage number of 56 vertebrae is much higher, being over 30 % while the percentage for 58 vertebrae is below 10. The mean is 56.69. These characters are typical of the Firth of Forth adult spring herring. Two samples from Aberdeen ($^{28}/_{6}$ 29 and $^{21\text{-}31}/_{7}$ 31), however, have obviously a mixed composition. These have been examined according to size groups and the results have given a descending scale in the mean number of vertebrae from the smaller to the larger sizes.

	Size Groups in mm.	No. examined	Mean Vertebrae S.
June 1929	36—50	305	56.98
	51—70	501	56.63
July 1931.....	41—50	73	57.23
	51—60	121	57.16
	61—70	133	56.82
	71—85	118	56.57

The characters of the smaller sized groups are identical with those of the previous samples which indicates spring herring of northern origin. The larger sizes, however, show characteristics which are more in harmony with those of the succeeding samples. The June sample, however, as shown by the graph, still comprises a mixture at the larger sizes. Representatives of the Firth of Forth spring herring in th transition stages have been taken in some years a Aberdeen, e. g. in July 1925, but the chances ar against both spring broods, Firth of Forth and nort of Scotland, occurring in the summer samples a Aberdeen during the same year.

The samples from Ronas Voe ($^{18}/_{6}$ 28), Aberdee ($^{10}/_{6}$ 27) and Firth of Forth ($^{25}/_{5}$ 28) are obviousl alike. The percentage frequencies for 55 and 58 vert brae are low, both being under 10 % while the doubl peak at 56 and 57 shows a slightly higher percentag at the former. These samples appear to be homo geneous both from the total size frequencies of th samples and from the regularity of the percentag curves, and are undoubtedly of autumn origin. Th presence of transition stages of autumn origin on th west side of the Shetlands is interesting and is i agreement with the drift of the larvae from the nort of Scotland as shown on the autumn chart. Th Aberdeen and Firth of Forth samples probabl originated from North Sea spawning grounds thoug it is difficult to decide on the exact locality of incidenc for each sample.

The size at which the keeled scales (K_2), i. e. th completion of metamorphosis, are fully develope shows on the whole a lower limit for larvae of sprin than for those of autumn incidence but there ar variations according to localities of origin. During th examination of those samples specimens were foun with some of the vertebrae carrying double spine. These have been eliminated from the above calcul tions. In the samples, for instance, at Aberdeen i June 1926 and in July 1931 the percentage of doubl spines was as high as 20 but the inclusion of thos in the calculations would rather have tended t increase than to lower the value of the mean.

Der Einfluss des „Nordschottischen Frühjahrsherings“ auf die Heringsbestände des Fladengrundes.

Von

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s ist seit langem bekannt, dass im Westen der dlichen Nordsee neben dem im Herbst laichen- Hering auch ein Frühjahrshering auftritt. Doch bisher die Rolle, die er bei der Bildung der schbaren Heringsschwärme dieses Gebiets spielt, tritten. Während von mir die Ansicht vertreten de, dass die Grundlage der Heringsfischerei auf Fladengrunde der Herbsthering bildet, dessen wärmen Frühjahrslaicher in jährlich und vielleicht jahreszeitlich wechselnden Proportionen beischt sind, nehmen andere Untersucher an, dass Frühjahrshering in den Beständen regelmässig wiegt.

e Richtigkeit meiner Anschauung kann ich jetzt weisen. Die Unterlage bietet das von Hamburg den Jahren 1931 und 1932 gesammelte und auf Rassenzugehörigkeit hin analysierte Material an heringen vom Fladengrunde, sowie die in den n 1922—1930 gemachten Alters- und Längenuchungen an Heringen gleicher Herkunft.

dem Jahre 1931 liegen rund 1200 Heringe vor, ilt auf 8 Proben aus der Zeit vom 28.VII. bis 23.X. Den Altersbestimmungen nach trat in der damals 4 Jahre alte Jahrgang 1927 mit 32 % hervor. Die mittlere Länge aller Tiere g 27.1 cm. bei einem Durchschnittsalter von 6.1 n und war damit relativ hoch. Nach dem Vor- von Hodgson wurde bei den Rassenunterngen besonderes Gewicht gelegt auf den Hauptang 1927.

wir es mit zwei Rassen zu tun haben, einer ahrsform und einer Herbstform, müsste zu der in der die Proben erhalten wurden, die erstnte als »recovering spent« nichtentwickelte Gonaden haben, während die Gonaden der Herbstrasse voll entwickelt sein sollten. Trennt man nach diesem Gesichtspunkte der Reife das gesamte Material in zwei Gruppen, so erhält man für die Summe der Wirbel (vert S) der »unreifen« Heringe ein fast symmetrisches Variationspolygon mit einem Maximum bei 57 Wirbeln. Es unterscheidet sich wesentlich von dem Variationspolygon der »reifen« Tiere, das ein Maximum bei 56 Wirbeln aufweist.

Berechnet man das Variationspolygon für alle 4-jährigen Heringe, so stimmt dieses mit dem für die unreifen Tiere im wesentlichen überein. Schon das ist ein Beweis dafür, dass der Jahrgang 1927 in der Hauptsache aus Frühjahrslaichern bestand. Da die mittlere Länge der Jahresklasse 1927 sehr hoch ist, zumal wenn man an die für den geschlechtsreifen Herbsthering geltende Regel denkt, nach der ein solcher Hering ebenso alt ist wie er cm. über 20 misst, hat man es bei dem Frühjahrshering offenbar mit einer schnellwüchsigen Form zu tun. Wählt man deshalb aus den 4-jährigen nur die grossen Heringe aus, d. h. diejenigen, die länger sind als 25 cm., dann erzielt man ein eingipfelig-symmetrisches Variationspolygon mit einem Maximum von 65 % bei 57 Wirbeln und das Mittel für vert S steigt auf 56.93, also nahezu auf 57. Diese Zahl wird durch die Untersuchungen von H. Wood, Aberdeen, bestätigt, der zudem einen sehr niedrigen Wert (14) bei den Kielschuppen (K_2) fand.

Wir besitzen damit für den aus dem Atlantik in die Nordsee einwandernden Frühjahrshering eine gute Beschreibung. Er hat 57 Wirbel, 14 Kielschuppen und ist raschwüchsig. Es ist daher nicht notwendig

Tabelle 1.

Die Heringe vom Fladengrund 1931.

	Z	22	23	24	25	26	27	28	29	30	31	32	33	S	M	%
.....	3	1	5	6	5	6	*	*	*	*	*	*	*	23	24.2	2
.....	4	—	14	23	59	157	97	28	8	*	*	*	*	386	26.1	32
.....	5	1	2	19	48	61	29	17	5	1	1	*	*	184	25.9	15
.....	6	*	1	3	29	59	56	25	9	3	1	1	*	187	26.6	16
.....	7	*	*	1	4	23	37	34	10	3	—	1	*	113	27.3	9
.....	8	*	*	*	1	25	56	61	10	4	*	*	*	157	27.4	13
.....	9	*	*	*	3	10	30	31	7	1	*	*	*	82	27.4	7
.....	10	*	*	*	2	6	12	13	6	1	—	1	1	42	27.7	4
.....	11	*	*	*	*	*	1	4	4	2	*	*	*	11	28.6	1
.....	12	*	*	*	*	2	1	5	—	—	1	*	*	9	27.8	1
.....	13	*	*	*	*	*	*	*	*	1	*	*	*	1	30.0	—
		2	22	52	151	349	319	218	59	16	3	3	1	1195	26.6 cm. + 0.5	
	%	—	2	4	13	29	27	18	5	1	—	—	—			

zu erörtern, in wieweit die bisher für den Herbsthering erhaltenen Merkmale (56.5 Wirbel, 15 Kielschuppen und Langsamwüchsigkeit) in allen Punkten zutreffen. Es genügt, dass sie zur Unterscheidung der beiden Rassen ausreichen.

In Tabelle 1 ist die Längen- und Alterszusammensetzung der 1931 vom Fladengrunde untersuchten Heringe angegeben. Durch Interpolation kann man, unter Benutzung der soeben angeführten Merkmale, feststellen, dass von den 3-jährigen Heringen rund 70 % Frühjahrslaicher waren. Von den 4-jährigen waren es sogar 85 %, von den 5-jährigen 46 %, von den 6-jährigen 31 %, während in den älteren Jahresklassen zusammen vielleicht noch 20 Stück zu der Frühjahrsform gehörten. Wir kommen damit zu 520 Frühjahrsheringen, das sind 44 %. Dieser hohe Prozentsatz wird im wesentlichen erreicht durch die Einwanderung eines einzigen Jahrganges, des von 1927.

Die genannten Zahlen werden durch Tabelle 2 bestätigt, in der die mittleren Längen für jede Altersklasse in den Jahren 1922—1932 gegeben werden. Wir sehen, dass 1931 die für die 3- und 4-jährigen Heringe errechneten Werte im Vergleich zu denen anderer Jahre sehr hoch sind, dass dagegen der Wert für die 5-jährigen niedriger ist als der für die 4-jährigen. Das entspricht dem um die Hälfte geringeren Anteil der Frühjahrsheringe an der Altersklasse 1926.

Tabelle 2.

Durchschnittslängen der einzelnen Altersgruppen 1922—1932.

Jahre	3	4	5	6	7	8	9
1922	22.3	23.2	25.8	27.0	28.1	28.8	30.0
1923	—	25.3	25.0	26.3	27.6	28.2	29.8
1924	22.5	24.4	25.3	26.1	27.4	28.7	29.9
1925	22.7	23.4	24.7	25.5	25.8	26.0	30.0
1926	24.0	24.2	24.4	25.3	26.2	27.2	28.5
1927	23.6	23.9	24.7	25.0	25.8	25.9	27.8
1928	22.8	26.1	26.5	26.5	26.6	27.3	27.5
1929	—	27.2	27.2	27.1	26.8	26.7	27.3
1930	24.1	25.3	26.8	27.2	27.7	27.6	27.5
1931	24.7	26.6	26.4	27.1	27.8	27.9	27.9
1932	22.9	24.6	25.8	26.5	27.0	27.8	27.8

Grundlegend verschieden sind die Verhältnisse im Jahre 1932. Untersucht wurden insgesamt mehr als 2500 Heringe aus der Zeit vom 30.VI. bis zum 27.IX. Bei einem Durchschnittsalter von 6.0 Jahren war ihre mittlere Länge 26.1 cm., d. h. bei fast demselben Alter wie 1931 um genau 1 cm. geringer. Der Altersverteilung nach gehörten 27.5 % zum Jahrgange 1927, der schon 1931, im Alter von 4 Jahren, in den Schwärmen stark hervortrat; 22 % gehörten zum Jahrgang 1928.

Auch aus dem Material von 1932 kann man eine ganze Anzahl von grossen, unreifen Heringen herausuchen, die alle die vorhin genannten Merkmale der Frühjahrslaicher besitzen, doch ist ihre Zahl wesentlich geringer als 1931. Ein Vergleich der mittleren Längen der verschiedenen Jahresklassen bestätigt dies. So sind die 4-jährigen Tiere im Jahre 1932 (Jahrgang 1928) 2 cm. kleiner als die gleichalterigen Heri im Jahre 1931 (Jahrgang 1927), und die entsprech den 5-jährigen 0.6 cm. kleiner. Der Jahrgang 19 wäre danach in der Zeit vom Sommer 1931 bis z Sommer 1932 nicht gewachsen, sondern 0.8 c kleiner geworden. Das ist natürlich nicht der Fall, hat sich inzwischen nur das Mischungsverhältnis v raschwüchsigen Frühjahrsheringen und langsamwa senden Herbstheringen verändert.

Stützt man sich auf diese Zahlen, um aus den Tabelle 3 zusammengefassten Längen- und Alte bestimmungen die Frühjahrsheringe auszuscheid so findet man unter den 3-jährigen Heringen 15 Frühjahrslaicher, unter den 4-jährigen 20 %, un den 5-jährigen 27 % und unter den 6-jährigen 31 Die Gesamtzahl der Frühjahrslaicher ist auf 414 v 2514 Heringen oder 16.5 % berechnet, gegen 44 im Jahre 1931. Die wichtigste Verschiebung ist b Jahrgang 1927 eingetreten, bei dem der Prozents der Frühjahrslaicher von 85 % auf 27 % gefallen

Vergleicht man in einer kleinen Tabelle die V änderungen des Anteils der Frühjahrsheringe an einzelnen Altersklassen, so wird man annehmen m sen, dass sich 1932 am stärksten die mittleren Län

	3	4	5	6 Jahr
1931.....	70	85	46	31 %
1932.....	15	20	27	31 %

der Altersklassen 3 und 4 gesenkt haben, bedeut weniger oder garnicht die der Gruppen 5 und 6. I trifft in der Tat zu, wie ein Blick auf Tabelle 2 le

Die Befunde der Jahre 1931 und 1932 zeigen d lich, dass die kombinierte Längen-Altersbestimm ein guter Masstab für die Beurteilung der Stärke Einwanderung von atlantischen Frühjahrsherin auf den Fladengrund ist. Es ist daher gerechtfert wenn wir an Hand der oben gegebenen Tabelle 2 suchen, auch für die Jahre 1922—1930 diesen fluss zu bestimmen. Wir finden dann von 1923—1 nur einen sehr geringen Einfluss der Frühjahrslaic auf die Bestände. Die 3-jährigen Tiere zeigen 1926 eine Erhöhung ihres Längenmittels über Norm, die 4-jährigen 1923. In beiden Fällen han es sich um in den Schwärmen nur schwach vertre Jahrgänge und die Erhöhung des Mittels ist nur bedeutend. Eine stärkere Erhöhung des Mittels ze 1922 die 5- und 6-jährigen Tiere, vielleicht auch 7- und 8-jährigen. Da in den Fängen dieser Sa die Altersstufen 5, 6 und 7 recht zahlreich vertr waren, ist für 1922 ein nicht unerheblicher Ein der Frühjahrslaicher anzunehmen.

In dem Zeitraum 1928—1931 ist ein starker fluss der Frühjahrsheringe spürbar. Die 3-jähr Tiere der Jahrgänge 1927 und 1928 zeigen 1930 1931 sehr bedeutende Steigerungen ihres Län mittels und die 4-jährigen in allen Jahren, vorne lich aber 1929. Dasselbe ist auch bei den 5-jähr Heringen und, wenn auch nicht so deutlich gesprochen, bei den 6-jährigen der Fall. Es han

Tabelle 3.

Die Heringe vom Fladengrunde 1932.

	Z	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	S	M	%
.....	2	1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1	19.0	—
.....	3	*	3	26	27	12	8	5	4	*	*	*	*	*	*	*	85	22.4	3
.....	4	*	1	7	30	148	167	110	68	16	2	1	*	*	*	*	550	24.1	22
.....	5	*	*	*	3	61	156	205	135	74	44	12	*	*	*	*	690	25.3	28
.....	6	*	*	*	*	5	30	69	91	85	22	3	*	*	*	*	305	26.0	12
.....	7	*	*	*	*	*	15	44	89	107	34	9	1	1	*	*	300	26.5	12
.....	8	*	*	*	*	*	1	13	46	60	68	19	3	1	1	1	213	27.3	9
.....	9	*	*	*	*	*	*	9	41	55	50	23	4	—	*	*	182	27.3	7
.....	10	*	*	*	*	*	*	7	28	40	22	13	4	2	*	*	116	27.2	5
.....	11	*	*	*	*	*	*	4	10	12	13	7	—	—	*	*	46	27.2	2
.....	12	*	*	*	*	*	*	*	2	4	1	6	3	1	1	*	18	28.6	1
.....	13	*	*	*	*	*	*	*	*	1	1	1	1	*	*	*	4	28.5	—
.....	14	*	*	*	*	*	*	*	*	1	—	—	*	*	*	*	1	27.0	—
.....	15	*	*	*	*	*	*	*	*	*	1	1	*	*	*	*	2	28.5	—
.....	16	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	—	—	—
.....	17	*	*	*	*	*	*	*	*	*	*	*	*	1	*	*	1	31.0	—
		1	4	33	60	226	377	467	514	455	258	95	16	6	2	1	2514	25.6 cm.	+ 0.5
	%	—	—	1	2	9	15	19	21	18	10	4	1	—	—	—			

abei um z. T. besonders starke Jahrgänge, wie n von 1924 und 1927. Auf eine zahlenmässige nung des Anteiles der Frühjahrsheringe wurde htet; die Jahre 1931 und 1932 zeigen, wie sehr wanken kann.

2 bestanden die Heringsschwärme auf dem ngrunde zu $83^1/_2$ % aus Herbstheringen. Die rung für das Phänomen der grossen Scharen scher Frühjahrsheringe in die nördliche Nord- wohl dieselbe, welche auch für die Ansammlung eringen im Skagerrak im Frühjahr als wahr- lich gilt. Es handelt sich offensichtlich um eine Fresswanderung von Heringen, die im Frühjahr icht hatten und zur Deckung ihres stark ge- ten Nahrungsbedürfnisses Wanderungen weit lie Grenzen ihres eigentlichen Wohngebietes unternehmen.

Tiere verlassen spätestens zur Zeit ihrer Geschlechtsreife den Fladengrund wieder, doch ist während der Dauer der Trawlheringsfischerei ein jahreszeitlicher Einfluss auf die Länge ihres Aufenthaltes in der Nordsee nicht zu bemerken. Anscheinend halten sich die atlantischen Gäste während des Sommers und Herbstes in der Nordsee auf.

Schliesslich lässt sich mit Hilfe von Einzelwägungen sehr genau der Einfluss der Frühjahrsheringe auf die Erträge des deutschen Trawlheringsfanges berechnen. 1931 beispielsweise waren von 146.3 Millionen Pfund in deutschen Häfen gelandeten Heringen mehr als 50 % = 75 Millionen Pfund auf dem Fladen gefangen. Wären damals an Stelle der Frühjahrsheringe Herbstheringe gefangen, so hätte das einen Minderertrag von 7 Millionen Pfund gegeben. Da jedoch 1931 die 4-jährigen Nordseeheringe auf dem Fladengrunde nur in geringer Zahl vorhanden waren, wäre der Verlust beim Ausbleiben der atlantischen Heringe ungefähr 3mal so gross gewesen.

Report concerning the Danish fishing of Small Plaice from the North Sea

By

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1. Investigations as to the amount (number and size) of undersized plaice landed in Denmark.

Protection is afforded to the stock of plaice in the North Sea by the Danish fishery law which enforces the following minimum size limits:—

	total length
Plaice for sale in Denmark.....	257 mm.
— - export[1]) 1. Oct.—28(29) Febr.	225 mm.
— - — 1. March—30. Sept..	240 mm.

[1]) landed at the North Sea and Skagerak coast (south of Tversted Beacon, incl. Esbjerg, Ringkøbing, Thyborøn and Lemvig harbours).

The permission to land plaice for export below 257 mm. in length has been cancelled for the period March 16th—May 31st, 1933.

The Danish plaice fishery in the North Sea consists of:—

1) Fishery for plaice which are sold unsorted and chiefly alive; a smaller part iced. They are caught almost entirely by "Kutters" which make two trips a week and fish during the summer mainly in Area B4 and during the winter mainly in A3. They are partly sold at the auctions and part direct to the wholesale fish merchant.
2) Fishery for plaice, to be killed and iced, and so sorted (in 5 market categories) from "Kutter making trips of 8—14 days, during the summ mostly in Area B1 and the outer part of Area C during the winter mostly in the outer part Area C2. They are all sold at the auctions.

Statistics as to the amount of plaice of the differe market categories sold at the auctions have been co lected since Jan. 1st. For the year 1932 no statisti as to the amount taken by the two different fishi methods are available. A more or less reliable estima is given below under heading **A.** for the "Kutte landings in Esbjerg. Most of the unsorted plaice a landed in Esbjerg (a little in the other North S harbours). About 100 "Kutters" from Esbjerg tak part in this fishery for live plaice.

The distribution according to length of the differe market categories of plaice, landed at Esbjerg, w investigated during July 1932 and from Dec. 19 onwards. The length of plaice sold unsorted, and t category "small" is given in Table 1.

Table 1.

Market measurements.

Relative number of plaice below 26.0 cm. in length landed at Esbjerg.[1])

	Category		Month	Year	Area	Depth m.	Promille of plaice					No. of Kutters invest.	No. o plaice invest
							< 22,0 cm.	22,0— 23,0 cm.	23,0— 24,0 cm.	24,0— 25,0 cm.	25,0— 26,0 cm.		
Sold unsorted	Whole catch		July	1932	B 4	24—36	1	5	61	142	206	7	987
			Dec.	1932	A 3	6—19	15	72	182	217	187	19	4152
			—	—	B 4	28					8	1	128
			—	—	C 2	51			3	29	106	1	350
			Jan.	1933	Graadyb	10—16	43	286	324	205	85	several boats	469
			—	—	A 3	9—11	28	201	302	229	109	2	597
			Febr.	1933	B 4	23—24			109	259	300	2	1032
			April	1933	B 4	22					5	1	924
	sorted as "small"[2])		Mar. 14	1933	B 4	23—24				41	263	2	505
			May	1933	B 4	24					42	2	575
Sold sorted	Whole catch		July	1932	B 1, C 2				1	12	15	12	
			Dec.	1932	C 2				12	59	154	12	
			Jan.	1933	C 2				4	42	149	1	
	sorted small		July	1932	B 1, C 2	26—56			1	20	43	10	1111
			Dec.	1932	C 2			2	10	61	100	14	2128
			Jan.	1933	A 3	11		4	161	284	265	1	236
			—	—	C 2	42—47			3	30	116	2	336
			Febr.	1933	B 4	40			2	114	144	1	563
			Mar. 18	1933	B 4	21				4	50	1	561
			April	1933	B 1	38				2		1	522
			May	1933	C 2	45					13	1	384

[1]) For kind permission to cite the measurements from 1933 and part of those from Dec. 1932 I am indepted to Dr. Å. V. Täning.
[2]) Not the same as "small" of plaice sold sorted.

he composition as to length during February and following months of the present years has been ormal on account of the bad conditions of the ket; for this reason the minimum size of plaice ded for export has been raised above the normal np. below under heading **B.**).

A. Normal catch of plaice below 24 cm.

Winter: The composition as to length during ember 1932 and January 1933 may be considered about normal for the winter months and it will seen that about 1·0 % of sorted plaice only was less n 24.0 cm., i. e. such a small part as to be quite ligible.

On the other hand about 27 % (in Dec.) and about % (in January) of the plaice sold unsorted, landed "Kutters" from A3, were below 24.0 cm. Out of small amounts of plaice of this market category ded from B4 and C2 during the winter but a quite igible part was below 24.0 cm. in length.

he catch during the winter months is proportion- low as shown in:—

Table 2.

Danish catch of plaice (tons) from the North Sea 1932 landed in the various nths at Esbjerg, Thyborøn, Skagen and Frederikshavn.

nth	Esbjerg Kutters	Esbjerg Motor-boats	Thyborøn Kutters	Thyborøn Motor-boats	Skagen	Frede-riks-havn	Total
...	33.1	20.0	2.2				55
...	366.1		3.1				369
...	1,119.5		39.9	9.2	1.0		1,170
...	1,477.0		66.1	24.7	5.0	1.6	1,574
...	1,530.6		89.9	16.4	3.3	3.6	1,644
..	1,559.9		109.7	1.3	6.6		1,678
...	1,098.7		197.6		6.5	1.4	1,304
..	1,240.2		289.7		18.0		1,548
...	801.6		155.2	8.8	40.0		1,006
...	579.0	35.0	137.9	16.1	40.0	0.6	809
..	797.8	100.0	77.0	25.6	12.0		1,012
...	477.4	120.0	13.6		0.7	0.5	612
	11,080.9	275.0	1,181.9	102.1	133.1	7.7	12,781

ring winter, moreover, a plaice fishery from r-boats with beam-trawl is carried out in Graa- o the North-West of Fanoe near Esbjerg and to ll extent immediately outside the Graadyb-Barre sandbank bounding the Graadyb from the open Sea). For this fishery special statistics are ted (Table 2); in 1932 the total catch was ons.

analysis of the length of the plaice taken by otorboat fishery was carried out during January and it showed that 4.3 % were below 22.0 cm. 55 % below 24.0 cm.

mmer: During the summer months the lowest size at which plaice may be landed is fixed at 24.0 cm. and the number of fish landed below this size is very small.

Number of undersized plaice landed in 1932.

During January, February and October, November, December 1932 a total of 2,253 tons of plaice was landed at Esbjerg from the Danish Kutter-fishery. According to information collected from the various fishery authorities at Esbjerg and from statistics published by the press about 1,683 tons of unsorted were landed and the rest, or some 570 tons, of sorted. From the market measurements during December it can be computed that 1 kg. sorted plaice equals 3.8 individuals and 1 kg. plaice, sold unsorted, 6.0 individuals.

During the months March to September 1932 a total of 8,828 tons of plaice were landed at Esbjerg from the Danish Kutter fishery. Out of this some 4,975 tons were landed and sold unsorted and about 3,853 tons sorted. From the market measurements during July 1932 it can be computed that 1 kg. unsorted plaice equals 5.1 individuals, and 1 kg. sorted plaice 2.5 individuals.

From this and from the promille of plaice of various lengths shown in Table 1, the number of plaice below 22 cm. and below 24 cm. landed at Esbjerg in 1932 has been calculated as shown in:—

Table 3.

Amount of plaice landed at Esbjerg from the Danish fishery in 1932.

		Weight, metric tons	Total number in thousands	Under 22.0 cm. ‰	Under 22.0 cm. Number in thousands	Under 24.0 cm. ‰	Under 24.0 cm. Number in thousands
Summer:							
Kutters	sorted	3,853	9,632.5	0		1	10
	unsort.	4,975	25,372.5	1	25.0	67	1,700
Winter:							
Kutters	sorted	570	2,166.0	0		14	30
	unsort.	1,683	10,098.0	15	151.0	269	2,716
Motorboats.....		275	2,255.0	43	97.0	652	1,470
Total.....		11,356	49,524.0		273.0		5,926

The yield of the Danish plaice fishery landed at Esbjerg is about 90 % of the total yield of the plaice fishery landed in Denmark from the North Sea, and consequently we notice that but a little more than 300,000 plaice below 22.0 cm. were landed in 1932, and between 6 and 7 million plaice below 24.0 cm. were landed. The number of plaice below 22 cm. landed during the winter is only due to the before mentioned uncertainty of the fishermen in sorting the plaice namely in judging whether a certain specimen is above or below the size limit. This is also true for the summer landings of plaice below 24 cm., and an equal number of plaice just above the size limit is thrown overboard with the majority of undersized plaice.

About 2 mill. of plaice below 24 cm. would unavoidably be landed in Denmark if the minimum-size was fixed at 24.0 throughout the whole year.

In 1932 a total of some 25 million plaice below 26 cm. in length was landed.

B. Landings of undersized plaice during the present year.

On account of the bad market conditions the admission of plaice below 25.7 cm. was withdrawn by law from March 16th to May 31st. It will be seen from Table 1 that before this date even the lowest sizes landed were somewhat higher than the allowed minimum both in February and in March. Thus, on March, 14th, only some 30 % of live plaice were below 26 cm., when sorted as "small" by the fish merchant for sale, and in May only 4 %. Although the sorting of "small" is rather variable, these figures give a more or less reliable picture of the change in the fishery.

Practically no plaice sold, killed and sorted, was below 24 cm. during February.

2. Estimations of the stock of plaice of the same sizes in the Southern North Sea.

The number of undersized plaice may be computed in two ways:

a) Stating from scientific fishing experiments the relative number of undersized plaice in proportion to the number of commercial plaice. From this the absolute number of undersized plaice may be computed from the supposition that the absolute number of commercial plaice can be stated from marking experiments, giving the percentage of recapture, and from statistics of the number taken by the commercial fishery (method of JOHANSEN and HEINCKE).

b) Directly from the quantitative scientific fishing experiments by means of the catch coefficient of the trawl.

Before Jan. 1933, the Danish fishery statistics were not quite sufficiently detailed to allow the use of the first procedure. By the last mentioned method, and taking the catch coefficient as about 25 % (HEINCKE), the number of plaice of the different sizes are as follows: in the Southern Horns Reef Area (between 55°00′ N. Lat. and 55°33′ N. Lat. and east of 6°00′ E. Long.) outside the 10 metres curve:

Number of plaice in millions:

Length in cm.	10.0—15.0	15.0—20.0	20.0—22.0	22.0—24.0	24.0—26.0	> 26.0
October 1930	73	81	16	18	14	26
May 1932...	22	150	44	23	7	71

In the Northern Horns Reef Area so far fishing experiments from May 1932 are the only ones available for the later years. The total number of plaice found inside this Area was about two thirds of that in the Southern.

On account of the size of the mesh in the trawl the Danish fishing experiments give the real number for plaice above about 12 cm. as most plaice belo 12 cm. escape.

During the spring fishing experiments a rath large proportion of plaice below 20 cm. are to b found inside the 10 meter line. In autumn the numbe of plaice of 10—20 cm. length found inside the 1 meter line is far less than that found between 10 an 20 metres.

3. Estimations with regard to the profit an loss which would be entailed in value and weigh if a size limit of e. g. 24 cm. was adopted for th whole year.

By weight the amount of plaice below 24.0 cn landed at Esbjerg, computed by means of the marke measurements, was about 500 metric tons during th summer of 1932 and in winter about 300 tons c plaice from the Kutter-fishery, and about 160 ton from the motorboat fishery. The last mentioned fisher is the only one which would suffer seriously by raisin the minimum to 24 cm. for the whole year. At preser plaice below 24 cm. constitute 58 % of the yield b weight of this fishery, and it is not possible for thes small boats to go further out in order to get large plaice. Of the plaice below 24 cm. caught from Kutte the whole of the landing during the summer and pa of that during winter is, as mentioned above, un avoidable even if the limit of 24 cm. is adopted for th whole year. The landings of plaice below 24 cm. pr vented by a minimum limit of this size amounts t about 400 tons, which constitute about 20 % of th total catch of plaice from Esbjerg during the wint months. This would seem to be a rather large par but it is of very little value. Moreover the presenc of these small plaice lower the price obtained for th larger plaice and for this reason, after the close c the temporary annulment of the minimum size c 24 cm., on May 31st, the amount of plaice belo 25.7 cm. landed has been in fact very small.

The diminution of the landings by 400 tons, hov ever, may be regarded as temporary only. The lo entailed by sparing undersized plaice will, in fact, b more than compensated for by the fact that the will grow up to the new size limit; but at preser our knowledge as to the constants necessary for ca culating the results of a higher size limit is to uncertain. We may state, however, that the amount c plaice handled by the fishery under a higher minimu size for some reasons will tend to be augmented, fo others diminished.

To the advantage counts that practically the sam number of plaice will be able to reach the new siz limit, as plaice of these sizes have practically no oth enemy than the fishermen, and accordingly attain greater value and weight. Moreover, the number c undersized plaice killed by the fishery, and not landed will be diminished because, with a higher size lim in force, certain parts of the nursery grounds mu be left alone by the fishery.

It may be taken for granted that this profit wi

be outweighed by the effect of a somewhat lower wth rate caused by the increased competition for d by a denser stock. From the earlier investigations eems that a protection of a stock of young plaice s not hinder the growth to such a degree as to eaten the recruitment of the stock, at all events it is not complete[1]). Further investigations are ded with regard to this point.

On the other hand a loss may possibly arise to a minor part of the Danish fishery because some of the inshore grounds may have to be abandoned since it would be unprofitable to fish them.

[1]) Aage J. C. Jensen, Rapports et Procès-Verbaux. Vol. LXXX, IV, 1932.

The Present Condition of the Plaice Stock in the Southern North Sea.

By

D. E. Thursby-Pelham, Lowestoft.

Two opposite opinions are current with regard the condition of the stock of plaice in the North . On the one hand it is considered that it is sfactory and that owing to the increased use he Danish seine the stock is fished more economi- y at the present time than was formerly the case. great increase in the weight of plaice landed ween 1925 and 1930 in comparison with former rs is adduced in confirmation. On the other hand, English fishing industry complain of the poverty he catches and the scarcity of any but the smallest

With regard to the first opinion there can be no bt that the total landings from the North Sea all nations have indeed increased. I have already wn[1]) (Tables 34 and 35, pp. 86 and 87) that average landings of the period 1925—1929 were h greater than in previous quinquennial periods. latest number of the Bulletin Statistique, dealing the landings in 1930, showed a fall in the total ht in that year but it was still greater than the ages for 1909—13, 1920—24 and 1925—29. It also been shown that the increased landings were largely of plaice caught with the seine net by Danes. The method of Danish seining is well wn to be economical in action, since the under- plaice are spared for recapture. If, however, the sh landings are excluded it will be found that the total landings of all the other nations combined, which were all taken principally with the trawl, have remained almost stationary, the average quantity in metric tons being as follows:—

1909—13: 42,863; 1920—24: 42,012;
1925—30: 42,786.

There is, therefore, no evidence that destruction of the undersized plaice by the trawl has diminished. At the same time the Danish catch has increased and raised the total landings.

Average landings of Plaice from the North Sea by all countries in metric tons:—

1909—13: 50,184; 1920—24: 47,437;
1925—29: 59,385; 1930: 61,798.

In order to find out whether the complaints of the English Fishing Industry are justified it is necessary to answer four questions.

1. Do the commercial statistics show that there has been a fall in the total English landings and in the abundance of plaice?
2. Are there fewer plaice in the sea available for capture or is the stock more or less stable numerically?
3. Is the stock of mature plaice diminishing materially?
4. Is there unmistakable evidence of a diminution in the average size of marketable plaice?

[1]) D. E. Thursby-Pelham. "Report on the English e Investigations during the years 1926 to 1930." F. Fish. Invest. Ser. I. Vol. XII. No. 5. 1932.

Table 1.

Plaice (tons) landed from the North Sea by British vessels at English Ports.

	1927	1928	1929	1930	1931	1932
n trawlers.....	16,946	16,692	17,515	16,733	15,489	13,811
r —	106	75	106	136	266	322
g —	2,668	2,214	2,068	1,534	1,193	955
n seiners	1,912	1,800	758	639	485	552
r —	193	272	206	201	380	244
d and Third Class vessels ..	194	192	159	138	170	165
Total...	22,019	21,245	20,812	19,381	17,983	16,049

1. The first question can be answered readily. The landings of plaice by British vessels during the last six years show a steady fall.

The number of hours' fishing of all types of British fishing vessels except motor trawlers and seiners has also declined as may be seen from the following comparison between 1927 and 1932.

Table 2.

Number of hours' fishing by certain types of first class British vessels working the North Sea.

	1927	1932
Steam Trawlers.....	1,906,821	1,575,726
Motor —	11,065	51,211
Sailing —	416,818	245,572
Steam seiners.....	153,091	43,361
Motor —	5,842	10,469

The general abundance of plaice in the North Sea is indicated by the quantity landed per 100 hours fishing.

From this table it is evident that while there has been little change from year to year in the general abundance of plaice over the whole North Sea, it has fallen very considerably in the Southern portion, with which this paper is concerned principally. The fall in abundance is most marked in the landings of sailing trawlers though that of the steam trawlers is far from negligible.

On the other hand the middle North Sea, which includes part of the main plaice grounds, shows very little alteration. Is it not a possibility that the decline in the Southern North Sea abundance is due to the fact that the fishing is carried out in an entirely uneconomical manner in that the trawl is the principal gear used and that there is unrestricted landing even of the very smallest plaice for utilization for fish meal in Holland and Germany; whereas in the middle North Sea a very considerable part of the fishing is carried out by the Danes, using the seine net, and further protecting the unmarketable fish by the enforcement of a size limit.

The answer therefore to the first question is that the landings of plaice in England are declining rapidly, that while there is no evidence of a decline in abundance in the Northern and Middle North Sea a marked decrease is shown in the Southern part.

2. The answer to the second question cann be given so satisfactorily. The English scienti experiments during recent years have been confin to investigations of the market landings at Lowest and Grimsby of plaice landed by steam trawle These landings constitute about 80 % of the to English landings from the North Sea but the work Grimsby has been carried out only for the past t years and is not of much value therefore in t connection. The following remarks therefore w relate only to the Lowestoft landings and main to the stock of plaice south of 54°30′ N.

On the market, plaice of less than 20 cm. are land seldom and the quantity brought to port betwe 20 and 24 cm. depends very greatly on the dema at the time for small fish, which fluctuates very co siderably from month to month and year to ye Many factors affect the demand; for example if the is a scarcity of little round fish for the fried fi shops, small plaice will be required and again t supply and price of plaice imported from Denma has a considerable influence. We cannot calcula therefore the abundance of plaice below 25 cm. wi any certainty, since it is not known what proporti of the catch below that length has been landed.

Before discussing the data it is desirable to s whether the landings of plaice were from appro mately similar areas in the same months in t different years. In order to test this I have adopt the same method used in my recent report[1]) and take into consideration only the rectangles wh over 500 hours' fishing had taken place by Lowest steam trawlers. The total landings from these re angles were added together and their percentage the total landings at the port, calculated. In the ca where comparisons are made between 4 or 5 ye (July, April and October) the rectangles where ov 500 hours' fishing had occurred in 3 out of 4 and out of 5 years respectively, have been used as w as those where over 500 hours' fishing had tak place in each month in the whole periods. Simila in December where investigations have been carri out for 6 years, the calculations are based on re angles where over 500 hours' fishing had occurred 4 out of the 6 years.

[1]) D. E. Thursby-Pelham. "Report on the Engl Plaice Investigations during the years 1926 to 193 M. A. F. Fish. Invest. Ser. II, Vol. XII. No. 5. 1932.

Table 3.

Landings of Plaice (cwt.) per 100 hours' fishing in the North Sea by British first class trawle landing at English Ports.

	Region and Sub-region	Landings per 100 Hours' Fishing 1927	1928	1929	1930	1931	19
Steam Trawlers.....	North Sea	16	16	17	16	17	1
	Northern North Sea	1	1	1	1	1	
	Middle North Sea	15	16	16	15	15	1
	Southern North Sea	33	30	33	29	28	2
Sailing Trawlers.....	Mainly Southern North Sea	13	11	11	10	8.5	
Motor Trawlers		19	15	19	13	15	1

The results obtained are shown in Table 4.

Table 4.

	Year	A Rectangles with over 500 hours' fishing	B Total landings from all fishing Cwt.	C Landings from A Cwt.	D Percentage of C to B
ril	1928	F2, G6, H6, J6,	4,185	2,106	50.3
	1929	J7, K6	12,806	10,369	81.0
	1930		6,489	4,495	69.3
	1931		3,782	2,009	53.1
	1932		3,498	2,665	76.2
y	1929	F5, G4, G6, H5,	9,489	3,786	39.9
	1930	H6, H7, J6, J7	4,923	4,117	83.6
	1931		6,360	5,004	79.3
	1932		5,310	4,513	85.0
.	1926	F5, G4, G5, G6,	5,132	4,266	83.1
	1929	H5, H6, H7, J7,	6,573	5,498	83.6
	1930	J8	6,614	5,785	87.5
	1931		6,358	5,871	92.3
	1932		3,931	3,265	83.1
.	1927	G2, G3, G4, G5,	5,703	4,150	72.8
	1928	H5, H7, J7, J8,	6,569	5,424	82.6
	1929	K6	4,102	3,322	81.0
	1930		4,499	3,170	70.5
	1931		4,689	3,426	73.1
	1932		3,904	2,323	59.5

is evident that the bulk of the fishing occurred in much the same areas in October and December also in July during the last three years; in July the fishing extended much further eastwards as spread over a wider area. In April the agree- was moderately good and there was considerable arity between 1929 and 1932. Since over 50 % e fishing took place in all five years in the same it cannot be said that widely different stocks of e were being fished.

ble 5 (page 28) gives figures from the whole collected at Lowestoft with the exception of e of the XI and older age groups which are ed owing to some slight irregularity in the ods of collection of the very large plaice.

ce, as already mentioned, it is possible to estimate the abundance of plaice of 25 cm. and over with eliability at Lowestoft it is necessary to subtract laice of below 25 cm. in order to obtain com- ns of the number landed per 100 hours' fishing. 6 shows the numbers on this basis.

Table 6.

Number of Plaice of 25 cm. and over ed at Lowestoft per 100 hours' fishing in certain months.

	1926	1927	1928	1929	1930	1931	1932
q.	—	—	6,133	7,201	7,983	8,236	4,962
.	—	—	—	8,727	4,534	5,567	6,531
.	8,020	—	—	5,101	4,382	6,436	3,816
.	—	3,124	2,538	2,977	2,108	2,047	1,782

The evidence produced in the different months is decidedly contradictory. In April there appears to have been steadily increasing abundance up to 1931 followed by a sharp fall in 1932. It has been shown in Table 4 that the landings in July 1929 are not comparable with those of the other years but from 1930 to 1932 the numbers rose steadily. In October it has been possible to make an estimate of the number landed in 1926; it must, however, be emphasised that this is not based on as reliable data as those of later investigations, nevertheless it certainly does not overestimate the numbers, particularly of the bigger fish, and the total is very much greater than that of the last four years — despite the marked rise in 1931; again there was a marked decline in 1932, which, however, as will be explained later, was probably exaggerated. The December landings, which are based as a rule on fish taken either at the spawning grounds or migrating to spawn, show an almost unbroken fall since 1928, particularly marked in 1932.

From these data it would appear (1) that during the last five years no great change has taken place in the number of plaice present in the sea during the spring and summer months; the yearly variations, as will be shown later, can be explained by the yearly fluctuations in the strength of the individual brood years and variations in the rate of growth.

(2) The number of plaice, however, has been much less during the last few years than it was seven or six years ago as shown by the comparisons with October 1926 and December 1927.

Fluctuations in the abundance of the various year classes have been dealt with very ably by Dr. Bückmann[1]). He has expressed his conclusions in a table (p. 208) by giving them a numerical value:—

Year class	1922	1923	1924	1925	1926	1927	1928	1929	1930	Average
Ca.	85	25	20	50	25	35	100	32	22	44

His results agree in the main with those obtained from the investigations of the Lowestoft landings. The differences that appear probably are due largely to the fact that at certain seasons of the year the landings at Lowestoft are from an area south of the German observations and do not at any time come from so far north as their more northerly samples.

Table 7 (page 29) gives the landings per 100 hours' fishing of each age group for the months of December, April and October. The July figures are omitted since the area fished in 1929 differed widely from those of subsequent years.

The data for the comparison between the 1926 and 1923 year class are somewhat inconclusive and contradictory in the Lowestoft landings; on the whole the 1926 year class appears to be slightly the stronger of the two; Dr. Bückmann ascribes the same value to them. The 1927 year class which he shows to be

[1]) A. Bückmann. Ergebnisse der Kontrolle der Schollenbevölkerung der Deutschen Bucht bis zum Jahre 1932. Berichte d. Deutschen wiss. Komm. f. Meeresforschung. N. F. Bd. VI. H. 3. 1932.

Table 5.

Numbers and percentages of Plaice in 5 cm. Groups landed at Lowestoft per 100 hours' fishing by English Steam Trawlers in certain months.

Date		15—19	20—24	25—29	30—34	35—39	40—44	45+	Total
April 1928	No. per 100 hrs.	78	4,256	4,278	1,564	219	64	8	10,46
	%	*0.7*	*40.7*	*40.9*	*14.9*	*2.1*	*0.6*	*0.1*	
1929	No. per 100 hrs.	414	12,043	5,697	1,017	424	58	5	19,65
	%	*2.1*	*61.3*	*29.0*	*5.2*	*2.2*	*0.3*	*0.0*	
1930	No. per 100 hrs.	377	4,104	6,110	1,524	313	34	2	12,46
	%	*3.0*	*32.9*	*49.0*	*12.2*	*2.5*	*0.3*	*0.0*	
1931	No. per 100 hrs.	—	2,756	5,869	2,121	212	33	1	10,99
	%		*25.1*	*53.4*	*19.3*	*1.9*	*0.3*	*0.0*	
1932	No. per 100 hrs.	10	6,537	3,688	1,094	152	23	5	11,50
	%	*0.1*	*56.8*	*32.1*	*9.5*	*1.3*	*0.2*	*0.0*	
July 1929	No. per 100 hrs.	—	3,649	7,122	1,163	389	43	10	12,37
	%		*29.5*	*57.5*	*9.4*	*3.1*	*0.3*	*0.1*	
1930	No. per 100 hrs.	235	3,492	3,406	765	318	36	9	8,26
	%	*2.8*	*42.3*	*41.2*	*9.3*	*3.8*	*0.4*	*0.1*	
1931	No. per 100 hrs.	—	5,414	3,738	1,605	169	46	9	10,98
	%		*49.3*	*34.0*	*14.6*	*1.5*	*0.4*	*0.1*	
1932	No. per 100 hrs.	—	4,150	5,185	1,140	127	73	6	10,68
	%		*38.9*	*48.5*	*10.7*	*1.2*	*0.7*	*0.1*	
Oct. 1926	No. per 100 hrs.	7	1,317	4,549	3,012	351	108+		9,34
	%	*0.1*	*14.1*	*48.7*	*32.2*	*3.8*	*1.2*		
1929	No. per 100 hrs.	0.4	1,120	2,894	1,742	395	61	9	6,24
	%	*0.4*	*17.9*	*46.3*	*27.9*	*6.3*	*1.0*	*0.1*	
1930	No. per 100 hrs.	—	3,637	4,251	894	170	56	11	9,01
	%		*40.3*	*47.1*	*9.9*	*1.9*	*0.6*	*0.1*	
1931	No. per 100 hrs.	—	3,696	4,467	1,626	263	63	17	10,13
	%		*36.5*	*44.1*	*16.0*	*2.6*	*0.6*	*0.2*	
1932	No. per 100 hrs.		3,051	2,540	1,036	172	42	26	6,86
	%		*44.4*	*37.0*	*15.1*	*2.5*	*0.6*	*0.4*	
Dec. 1927	No. per 100 hrs.	—	422	1,435	701	706	198	84	3,54
	%		*11.9*	*40.5*	*19.8*	*19.9*	*5.6*	*2.4*	
1928	No. per 100 hrs.	4	177	507	1,307	399	262	63	2,71
	%	*0.1*	*6.5*	*18.6*	*48.1*	*14.7*	*9.6*	*2.3*	
1929	No. per 100 hrs.	1	275	1,521	632	570	191	63	3,25
	%	*0.0*	*8.5*	*46.8*	*19.4*	*17.5*	*5.9*	*2.0*	
1930	No. per 100 hrs.	—	150	780	883	265	131	49	2,25
	%		*6.6*	*34.5*	*39.1*	*11.7*	*5.8*	*2.2*	
1931	No. per 100 hrs.		726	951	525	352	154	65	2,77
	%		*26.2*	*34.3*	*18.9*	*12.7*	*5.6*	*2.4*	
1932	No. per 100 hrs.		2,815	1,109	429	131	96	17	4,59
	%		*61.2*	*24.1*	*9.3*	*2.8*	*2.1*	*0.4*	

+40+

less strong than that of 1925 seems to have about the same value, but again there are slight contradictions. The only comparison available between the 1928 and 1922 year classes agrees at first sight with Dr. Bückmann's conclusion that the 1928 year class was the richest recorded, but the number actually landed of small fish differed very greatly in October 1926 and 1932 as may be seen in table 5. In the case of the IV-group under discussion, in 1926 only 616 were landed per 100 hours' fishing below 25 cm. and in 1932, 2,211; if therefore this difference of 1595 fish in the number landed be subtracted from the figure given for 1932, the relative strength of the year class appears as 3,734 for the 1922 year class and 3,2 for that of 1928. It may well be, however, that t 1928 year class was more heavily fished than th of 1922 prior to reaching the IV-group and taki this into consideration it is justifiable to regard the as approximately of the same strength.

The estimated strength of the 1929 year class aga differs. Dr. Bückmann shows it to be superior those of 1923 and 1924, but in the October comparis it was very much less plentiful than the 1923 ye class, despite the fact that many more of the small

Table 7.

stimated landings (number) per 100 hours' fishing of Plaice landed by English Steam Trawlers at Lowestoft in certain months.

	Age Groups											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI+	Total
ec. 1927		184	453	416	1318	721	245	134	41	34	132	3,678
ear of Birth ...		(1925)	(1924)	(1923)	(1922)	(1921)	(1920)	(1919)	(1918)	(1917)		
ec. 1928	2	61	438	391	306	842	433	144	67	36	73	2,793
ear of Birth ...	(1927)	(1926)	(1925)	(1924)	(1923)	(1922)	(1921)	(1920)	(1919)	(1918)		
ec. 1929	1	268	544	819	338	299	612	216	96	59	72	3,324
ear of Birth ...	(1928)	(1927)	(1926)	(1925)	(1924)	(1923)	(1922)	(1921)	(1920)	(1919)		
ec. 1930		197	585	514	463	184	82	155	56	23	67	2,326
ear of Birth ...		(1928)	(1927)	(1926)	(1925)	(1924)	(1923)	(1922)	(1921)	(1920		
ec. 1931		56	1316	610	251	216	97	98	92	34	43	2,813
ear of Birth ...		(1929)	(1928)	(1927)	(1926)	(1925)	(1924)	(1923)	(1922)	(1921)		
ec. 1932		215	729	2819	520	126	84	38	21	42	71	4,665
ear of Birth ...		(1930)	(1929)	(1928)	(1927)	(1926)	(1925)	(1924)	(1923)	(1922)		
ril 1928		37	3157	2748	1453	2241	612	174	35	10	24	10,491
ear of Birth ...		(1926)	(1925)	(1924)	(1923)	(1922)	(1921)	(1920)	(1919)	(1918)		
ril 1929		1099	6087	7112	2829	637	1249	394	196	63	56	19,722
ear of Birth ...		(1927)	(1926)	(1925)	(1924)	(1923)	(1922)	(1921)	(1920)	(1919)		
ril 1930		274	3755	3576	3796	583	178	213	71	12	12	12,470
ar of Birth ...		(1928)	(1927)	(1926)	(1925)	(1924)	(1923)	(1922)	(1921)	(1920)		
ril 1931			1532	5305	2412	1281	156	198	73	35	15	11,007
ar of Birth ...			(1928)	(1927)	(1926)	(1925)	(1924)	(1923)	(1922)	(1921)		
ril 1932		48	816	7701	2204	387	217	63	28	47	28	11,539
ar of Birth ...		(1930)	(1929)	(1928)	(1927)	(1926)	(1925)	(1924)	(1923)	(1922)		
t. 1926		135	1432	3734	2545	?	?	?	?	?		ca. 9,344
ar of Birth ...		(1924)	(1923)	(1922)	(1921)							
t. 1929	4	849	1833	1849	821	233	506	103	44	16	35	6,293
ar of Birth ...	(1928)	(1927)	(1926)	(1925)	(1924)	(1923)	(1922)	(1921)	(1920)	(1919)		
t. 1930		1141	4754	2197	596	99	50	131	33	15	39	9,055
ar of Birth ...		(1928)	(1927)	(1926)	(1925)	(1924)	(1923)	(1922)	(1921)	(1920)		
t. 1931		953	5014	3250	615	157	53	26	45	19	25	10,157
ar of Birth ...		(1929)	(1928)	(1927)	(1926)	(1925)	(1924)	(1923)	(1922)	(1921)		
t. 1932		200	966	4863	559	102	82	23	11	40	28	6,874
ar of Birth ...		(1930)	(1929)	(1928)	(1927)	(1926)	(1925)	(1924)	(1923)	(1922)		

were landed in the later year. In December, vever, it is apparently stronger than the 1924 year s but again the difference in the size of the fish led must be taken into consideration. Only 193 ce of the III-group below 25 cm. were landed per hours' fishing in 1927 whereas in 1932 the number 595. The comparative strength therefore of plaice 5 cm. and over was 260 for the 1924 and 134 for 1929 year classes. On the basis of the Lowestoft stigations the strength of the various year classes be summed up as follows:—

1922	1923	1924	1925
Exceptionally good	Very poor	Very poor	Good

1927	1928	1929
Good	Equal to 1922	Very poor

he effect, however, of the rate of growth of these ous year classes must also be taken into consideration, for this inevitably must affect the number of plaice of over 25 cm. in the earlier age groups. According to Dr. Bückmann the year classes of 1920—1923 and of 1928 and 1929 grew very much slower than those of 1924 to 1927, and of these the 1926 year class grew most quickly. He ascribes the slow growth rate of the 1928 and 1929 year classes to over-crowding owing to the great density of the stock of the 1928 class. While confirming his opinion that they were indeed small for their age, since they appeared in relatively very small numbers in the landings as the III-group, I would suggest that factors other than over-crowding, in the sense that the 1920—1922 year classes were over-crowded, may have had a considerable influence. In the autumn of 1922 Dr. Kirstine Smith showed that there was a very great density of plaice of the 1920 to 1922 year classes on the Horns Reef nursery grounds. In 1928 to 1930 the density cannot have been nearly so great since there was only one really strong year class present. While agreeing that this would tend to slacken the

growth rate, in my opinion this was due partly to the effect of the very cold weather in the early months of 1929. It is known that the inshore grounds were frozen and that many flat fish died in consequence, it is therefore extremely probable that the food on which the young fish live also suffered a heavy mortality and in consequence was insufficient. Again it is quite possible that the greater part of the brood spawned in the winter of 1928—29 were killed in the early stages by the cold and that only the larvae produced at the extreme end of the spawning season survived and thus the stock got a very late start.

The effect of fluctuation in the abundance of the year classes and of the rate of growth, on the landings of plaice of 25 cm. and over can now be examined.

In April, when the fishing is mainly on the stock migrating from the coast, the number landed depends principally on the stock of plaice present of the IV- and V-age-groups (the III-group is, as a rule, still too small to be marketable in large numbers). If one or both of these age groups are from good year classes the number landed will be high and a corresponding reduction will occur when one or both are poor.

Table 8.

Number of Plaice of 25 cm. and over, landed per 100 hours' fishing in April.

Year	1928	1929	1930	1931	1932
IV-group.....	1,422	2,684	2,313	3,815	2,440
Year class ...	(1924)	(1925)	(1926)	(1927)	(1928)
V-group	1,118	1,373	3,529	2,156	1,740
Year class ...	(1923)	(1924)	(1925)	(1926)	(1927)
Total...	6,133	7,201	7,983	8,236	4,962
% of IV- and V-age-group to the total over 25 cm.....	41.4	56.3	73.2	72.5	84.2

This is very evident in Table 8. The 1923 and 1924 year classes were poor, consequently the number landed was low in 1928. In 1929, not only was the 1925 year class strong but the cold weather had the effect of causing an unusual spring migration of fish to the grounds fished from Lowestoft and the number rose. In 1930 the 1925 year class was stronger as the V- than as the IV-group in the previous year and the 1926 year class, owing to its more rapid growth, contributed a high number of fish of over 25 cm. In 1931 the 1927 year class which again had grown more quickly than that of 1925 was present in greater numbers and a slightly higher level was reached. Although, however, the IV- and V-groups in 1932 were from a very good and a good year class respectively there was a sudden drop in the number landed. This was doubtless due to the poor growth of the 1928 year class so that but a small proportion had exceeded 24 cm. The 1927 year class, perhaps owing to its having reached a marketable size so quickly was very much reduced between the IV- and V-age-groups. There has certainly been a tendency for the year classes of 1926 and 1927 to be reduced more rapidly between these age groups than was the case of earlier classes. Thus the rate of reduction has been as follows:

Table 9.

Percentage reduction (—) or increase (+) between the landings of the IV- and V-age-groups per 100 hours' fishing.

Month	Year Classes 1923	1924	1925	1926	1927
April ...		—3 %	+31 %	—7 %	—54 %
Oct.....			—63 %	—65 %	—80 %
Dec.....	—17 %	—3 %	—39 %	—50 %	—48 %

In July, as already said, the 1929 landings are not comparable and so they are omitted. By this month, if it has grown rapidly, the III-group will be sufficiently large to have an effect on the number landed, as in 1930 with the 1927 year class; but since the IV-group was from the poor year class of 1926 the total landings for that year were not high. In the following two years they rose when the 1927 and 1928 year classes, respectively, reached their maximum abundance in the July landings.

Table 10.

Number and percentage of Plaice of 25 cm. and over landed per 100 hours' fishing at Lowestoft in July 1930—1932.

Year	Age Group...	II	III	IV	V	VI+	Total
1930	No. per 100 h.	50	1906	1495	696	387	4534
	%.....	*1.1*	*42.0*	*33.0*	*15.4*	*8.5*	
	Year class ..	1928	1927	1926	1925	1924—	
1931	No. per 100 h.	—	937	2553	1317	760	5567
	%.....	—	*16.8*	*45.9*	*23.7*	*13.6*	
	Year class ..	—	1928	1927	1926	1925—	
1932	No. per 100 h.	19	347	4454	1347	364	6531
	%.....	*0.3*	*5.3*	*68.2*	*20.6*	*5.6*	
	Year class ..	1930	1929	1928	1927	1926—	

The October figures show the great contrast between the number landed per 100 hours in 1926 and the last four years. Here the effect, not only of fluctuation in the strength of the year classes and of the rate of growth, but also of the increased intensity in the fishing of the North Sea plaice stock can be seen.

It has been shown that the landings from the North Sea were very much higher from 1925 onwards, in consequence the stock of plaice present in 1926 had not been so heavily fished as it was in the succeeding years. In October 1926 the majority of the landings were of the 1922 and 1921 year classes as the IV- and V-age-groups. The 1921 year class in particular bulked far more largely than any succeeding V-group, partly no doubt because of its high abundance and low growth rate but also because it had not been so

Table 11.

Number of Plaice of 25 cm. and over, anded at Lowestoft per 100 hours fishing in October, of certain Age Groups.

ar	Age Group...	II	III	IV	V	VI+	Total
26	No. per 100 h.	35	886	3118	2481	1500	8020
	%.....	*0.4*	*11.0*	*38.9*	*30.9*	*18.7*	
	Year class...	1924	1923	1922	1921	1920—	
29	No. per 100 h.	424	1389	1597	800	891	5101
	%.....	*8.3*	*27.2*	*31.3*	*15.7*	*17.5*	
	Year class...	1927	1926	1925	1924	1923—	
30	No. per 100 h.	130	2557	1771	596	328	5382
	%.....	*2.4*	*47.5*	*32.9*	*11.1*	*6.1*	
	Year class...	1928	1927	1926	1925	1924—	
31	No. per 100 h.	173	2638	2711	615	299	6436
	%.....	*2.7*	*41.0*	*42.1*	*9.6*	*4.6*	
	Year class...	1929	1928	1927	1926	1925—	
32	No. per 100 h.	19	343	2657	542	255	3816
	%.....	*0.5*	*9.0*	*69.6*	*14.2*	*6.7*	
	Year class...	1930	1929	1928	1927	1926—	

The VI+ and Total in 1926 are estimates only.

rily fished in its earlier years as the 1924—1927 r classes. Again the fish of the VI and older age ips were much more numerous and there cannot much doubt that this was due to the stock having n more spared. The whole evidence points to a e rapid depletion of the stock though the great fall ween the numbers in 1931 and 1932 probably is ggerated by the unfavourable weather conditions October 1932. The winds during this month were stronger and more sustained than in 1930 and ; this would inevitably result in a loss of fishing er and in consequence fewer fish would be taken he trawl. This is borne out by the 1927 brood aring in fewer numbers than the 1926 year class he previous October, whereas in all other com- sons at other seasons with one exception, for h the reason has already been given, it was the nger of the two in the IV or V-age-groups. All ge groups therefore may be regarded as showing than their real strength. At a guess they might aised by 25 % which would give more probable es:—

roups ...	II	III	IV	V	VI+	Total
	24	429	3321	677	319	4770

hen, as in December, it is the mature fish that most sought after, it is the abundance of the V older age groups that mainly affect the number aice landed. The more rapid reduction of these fish has had a great influence on the landings. decline in numbers has been steady, except in when the quickly growing 1925 year class, as the roup was probably the cause of the increase. In over 60 % of the plaice landed were of the 1928 year class as the IV-group and there were 76 % fewer fish of the VI and older age groups than were present in 1927.

Table 12.

Number and percentage of Plaice of 25 cm. and over landed per 100 hours' fishing at Lowestoft in December 1927—1932.

Age Group	II	III	IV	V	VI+	Total
December 1927 ..	54	260	365	1274	1171	3124
%.....	*1.7*	*8.3*	*11.7*	*40.8*	*37.5*	
Year class.....	1925	(24)	(25)	(22)		
December 1928 ..	22	351	343	303	1519	2538
%.....	*0.9*	*13.8*	*13.5*	*11.9*	*59.9*	
Year class.....	1926	(25)	(24)	(23)		
December 1929 ..	171	448	754	332	1272	2977
%.....	*5.7*	*15.0*	*25.3*	*11.2*	*42.7*	
Year class.....	1927	(26)	(25)	(24)		
December 1930 ..	110	530	506	463	499	2108
%.....	*5.2*	*25.1*	*24.0*	*22.0*	*23.7*	
Year class.....	1928	(27)	(26)	(25)		
December 1931 ..	11	703	543	251	539	2047
%.....	*0.5*	*34.3*	*26.5*	*12.3*	*26.3*	
Year class.....	1929	(28)	(27)	(26)		
December 1932 ..	2	134	1090	282	274	1782
%.....	*0.1*	*7.5*	*61.2*	*15.8*	*15.4*	
Year class.....	1930	(29)	(28)	(27)		

3. From the figures given in Table 12 for December it will not be a matter of surprise to find that the number of mature plaice has declined very markedly during the past three years. For the purpose of calculating the number of mature plaice the landings per 100 hours' fishing at Lowestoft in December 1927 to 1932 and at Grimsby in 1931 and 1932 have been used, since in this season the fishing is principally on the grounds where the fish are either spawning or on the spawning migration. It has been necessary to fix an arbitrary size which accords most nearly to that of previous investigations on the size when the majority of plaice have attained maturity. Thus all females of 35 cm. and over and all males of 30 cm. and over have been treated as mature and those below these lengths as immature. On this basis the following figures were obtained. The XI and older age groups which were underestimated in all years prior to 1932 in the Lowestoft landings are included, also the plaice below 25 cm. which were omitted in the last section.

It is the decline in mature female plaice that causes apprehension. Whether the scarcity has reached a point sufficient to endanger the stocks of the future cannot be known at present. It is, however, worthy of note that there were more than twice as many mature female plaice landed per 100 hours' fishing in December 1928, when the last really good year class of plaice was spawned, than there were in 1932 at Lowestoft. The decline in the abundance of mature males is of less importance since they reach maturity

Table 13.

Number of Mature and Immature Plaice landed at Lowestoft and Grimsby per 100 hours fishing in December of certain years.

Lowestoft

Year	Category	Mature ♀	Mature ♂	Immature ♀	Immature ♂	Total	Year	Mature ♀	Mature ♂	Immature ♀	Immature ♂	Total
1927	Large and Best ..	164.0				164	1930	104.0				104
	Best Medium.....	230.4	69.6			300		109.6	26.4			136
	Small Medium....	164.9	201.1	3.0		369		124.1	26.9			151
	Best Small.....	128.8	554.7	148.5		832		63.3	147.8	140.9		352
	Small.....	—	112.2	659.7	1241.1	2013		4.1	333.5	569.3	370.1	1277
	Dead Small	Not Distinguished						—	—	150.6	155.4	306
	Total.....	**688.1**	**936.6**	**811.2**	**1241.1**	**3678**		**405.1**	**534.6**	**860.8**	**525.5**	**2326**
1928	Large and Best ..	125.0				125	1931	111.0				111
	Best Medium.....	197.0	26.6	1.4		225		133.5	7.5			141
	Small Medium....	171.5	24.5	—		196		122.6	14.4			137
	Best Small.....	182.0	205.5	143.5		531		170.0	53.6	30.4		254
	Small.....	5.8	719.2	526.3	327.7	1579		3.2	308.8	281.7	135.3	729
	Dead Small	—	—	65.3	71.7	137			11.3	833.1	596.6	1441
	Total...	**681.3**	**975.8**	**736.5**	**399.4**	**2793**		**540.3**	**395.6**	**1145.2**	**731.9**	**2813**
1929	Large and Best ..	141.0	1.0			142	1932	117.0				117
	Best Medium.....	195.8	23.2			219		96.8	10.2			107
	Small Medium....	210.0	30.0			240		81.0	39.0	2.0		122
	Best Small.....	67.6	398.5	32.6	2.3	501		13.7	108.5	131.2	7.6	261
	Small.....	—	236.5	750.3	1003.2	1990		—	95.0	325.6	416.4	837
	Dead Small	—	3.1	12.4	216.5	232		—	—	45.1	3175.9	3221
	Total...	**614.4**	**692.3**	**795.3**	**1222.0**	**3324**		**308.5**	**252.7**	**503.9**	**3599.9**	**4665**

Grimsby

1931	Large.....	44.0				44	1932	46.0				46
	Large and Best ..	100.0				100		105.0				105
	Best Medium.....	158.6	3.4			162		114.1	22.9			137
	Middles.....	173.0	33.0			206		117.0	90.3	0.7		208
	Big Small.....	175.2	114.8	14.0		304		113.1	120.3	47.6		281
	Small.....	2.2	122.6	273.1	194.1	592		1.5	181.7	219.9	66.9	470
	Chats.....			590.8	840.2	1431				514.4	397.6	912
	Total...	**653.0**	**273.8**	**877.9**	**1034.3**	**2839**		**496.7**	**415.2**	**782.6**	**464.5**	**2159**

earlier; it has been very rapid and unbroken, however, in the Lowestoft landings. This has not been the case at Grimsby as it will be noticed that considerably more mature males were landed per 100 hours' fishing in 1932 than in 1931. There were, however, 24 % fewer mature females landed at this port last year.

A very fair picture of the general abundance of mature plaice in the North Sea can be obtained by combining the data from the two ports for the last two Decembers, since the landings from these two ports represent well over 80 % of the total landings by British Steam trawlers in the North Sea:—

	Mature ♀	Mature ♂	Immature ♀	Immature ♂
1931.....	631.9	301.9	940.4	974.0
1932.....	463.4	385.8	732.7	1,028.1

The number of mature female plaice has thu fallen by nearly 27 % in the last year. The numbe of mature males it is true has risen owing to th considerable increase in the landings at Grimsby bu it must be remembered that these are raised figure from comparatively small samples and too muc emphasis must not be laid on the proportion of ma to female.

The distribution of females of 35 cm. and over i each age group is given in Table 14.

From these figures it is evident that the prospec of an improvement in the numbers of mature femal are not hopeful. The 1926 and older year classes ha reached or passed their zenith and little if an increase can be expected in the number of the 192 year class since, as may be seen in Table 7, it h already been greatly reduced. The 1928 year cla should show a considerable increase but this alon

Table 14.

mber of Female Plaice of 35 cm. and over landed at Lowestoft and Grimsby per 100 hours' fishing in December (Year Class in brackets below).

Lowestoft

Year	Age Groups III	IV	V	VI	VII	VIII	IX	X
928.....	3.3 (1925)	7.7 (1924)	53.6 (1923)	189.4 (1922)	169.8 (1921)	83.8 (1920)	64.6 (1919)	35.3 (1918)
929.....		13.8 (1925)	25.7 (1924)	31.8 (1923)	183.4 (1922)	161.1 (1921)	73.0 (1920)	53.7 (1919)
930.....	1.7 (1927)	14.6 (1926)	55.3 (1925)	42.0 (1924)	35.2 (1923)	119.5 (1922)	46.3 (1921)	22.0 (1920)
931.....	5.5 (1928)	27.7 (1927)	74.3 (1926)	125.1 (1925)	64.3 (1924)	78.9 (1923)	88.4 (1922)	33.0 (1921)
932.....		10.3 (1928)	38.2 (1927)	36.7 (1926)	60.3 (1925)	33.3 (1924)	18.1 (1923)	39.9 (1922)

Grimsby

931.....	0.9 (1928)	37.4 (1927)	67.9 (1926)	113.1 (1925)	78.5 (1924)	82.1 (1923)	113.0 (1922)	73.7 (1921)
932.....		21.2 (1928)	78.7 (1927)	81.6 (1926)	76.9 (1925)	48.7 (1924)	18.4 (1923)	77.5 (1922)

nlikely to do more than keep up the stock at the ent low level. When it too has passed its maxi- m the outlook is gloomy indeed, since the oming two year classes are so poor and there o good brood yet in sight.

The fourth question as to whether there has a noticeable decrease in the average size of the e stock can be answered most readily by referring he landings of each trade category at Lowestoft ng the last four years. We cannot legitimately pare the earlier landings as the sorting of plaice ged somewhat in 1929; the monthly measure- ts of each trade category varied little from 1929 31. In 1932, the firm landing the greatest quantity laice added a further category of "good small" e range lay between "small" and "best small". has been included in "best small" by the col- r of statistics. At the same time the size of e in "best small" and "small medium" was raised bout 1 to 2 cm. and the size of "small" was ly lowered. This has had the effect of artificially ing the quantity landed of "small medium" and asing the amount of "best small". The differ- ences are not so great, however, as to invalidate the conclusions to be drawn from Table 15.

Table 15.

ndings of Plaice (cwt.) per 100 hours' shing at Lowestoft by English Steam Trawlers.

	1929	1930	1931	1932
, Large, Best...	2.2	2.2	2.1	2.2
Medium	1.9	1.4	1.3	1.2
Medium	2.2	1.6	1.3	1.2
Small.....	6.3	4.6	3.5	2.4
.....	25.8	21.9	14.4	7.5
Small	1.9	2.7	8.2	14.8
Total...	40.3	34.4	30.8	29.3

The size of the plaice in the various categories varies somewhat in the course of the year and the categories overlap somewhat but on the average the majority of the plaice fall within the following size groups in centimetres.

	Dead Small	Small	Best Small	Small Medium	Best Medium	Large and Best etc.
	20—25	25—31	31—36	36—40	40—45	45+
Mean cm.	23	27	33—34	37—38	41—42	

From these data and Table 15 it is established beyond doubt that the size of the plaice landed is decreasing at a rapid rate since the landings of all categories except "dead small" have fallen. This is more noticeable in the categories of small, medium, best small, and small. A rough estimate of the number of plaice landed per 100 hours' fishing in these categories and of "dead small" can be obtained by applying the number of plaice per cwt., calculated from the weighings made in April, July, October and December of the four years to the average yearly landings of these categories in Table 15.

	1929	1930	1931	1932
Small Medium.....	209	152	124	114
Best Small.....	813	593	452	310
Small.....	6063	5146	3384	1762
Dead Small.....	737	1047	3182	5742

It is certain that the complaint of the fishing industry that the plaice stock in the southern North Sea is showing a diminution in average size is justified.

Estimation of the Number, Weight and Value of Plaice below 23 cm. in length landed at English Ports by British vessels in 1932.

By

D. E. Thursby-Pelham, Lowestoft.

The following estimates concerning the landings of plaice, and in particular plaice below 23 cm. are submitted in response to the questions raised by Mr. Aage J. C. Jensen and circulated by Professor W. Mielck.

1. Weight.

a) The total landings of plaice from the North Sea by all classes of British vessels landing at English ports in 1932 was 321,049 cwt.

b) Investigations have been carried out at Grimsby and Lowestoft on the size of plaice landed at these two ports by 1st class Steam Trawlers from the North Sea. The weight of plaice landed by these vessels during 1932 was 241,640 cwt. or 75.3 % of the total English North Sea plaice landings.

c) It has been estimated that 2,766 cwt. at Grimsby and 6,450 cwt. at Lowestoft consisted of plaice of below 23 cm.; total 9,216 cwt. or 3.8 % of the landings by Steam Trawlers at these ports. On this basis, admittedly unlikely to be strictly accurate, the English landings of plaice below 23 cm. may be estimated at 12,200 cwt.

2. Number.

a) The total number of plaice landed by Steam Trawlers at Grimsby and Lowestoft has been calculated to have been:— Grimsby, $30^1/_2$ million, Lowestoft, $15^1/_4$ million, Total, $45^3/_4$ million, in 1932.

b) Similarly the number of plaice under 23 cm. has been calculated to have been:— Grimsby, 1,375,000. Lowestoft, 3,150,000. Total, 4,525,000, or 9.9 % of the total number landed.

c) By raising, the number landed from the North Sea by all classes of English vessels is estimated at 61 million plaice, of which 6 million were below 23 cm.

3. Value.

The value of the total landings of North Sea plaice by Steam Trawlers at Lowestoft and Grimsby in 1932 was calculated at:— Grimsby, £450,000; Lowestoft, £115,000; Total, £565,000. Of these the value of plaice under 23 cm. was calculated at:— Grimsby, £2,688; Lowestoft, £2,900; Total, £5,588, or 1.0 % of the total landings by these vessels.

There are no available data with regard to the value of the remaining 24.7 % of the English North Sea landings, therefore the estimate of £7,000 as the total value of plaice below 23 cm. obtained by calculations made on the basis of the Lowestoft and Grimsby figures, can be only very approximately correct.

Note.

The landings of plaice at Lowestoft are principally from the area south of 54°30′ N.; the Grimsby vessels while fishing much the same area, operate also further north and to the Eastern grounds off the Danish coast. The range of size therefore of the plaice actually caught by the vessels fishing from the two ports probably does not vary to any great extent, but a greater proportion of plaice below 23 cm. are landed at Lowestoft than at Grimsby since the demand differs at the two markets.

It is not possible to give any idea of the number of plaice rejected at sea as too small for the market during 1932, since measurements at sea have been discontinued except on a small scale. Dr. Russell agrees that the rough estimate given in his paper (Rapport et Procès-Verbaux, Vol. LXXX, 1932) of $8^1/_2$ millions is probably far too low. The number moreover, inevitably must fluctuate from year to year since it is dependent on the stock of undersized plaice present, which again is dependent on variations in the strength of the individual year classes of plaice.

4. Have Changes appeared?

The question raised by Dr. Blegvad as to "whether changes have appeared in the fishery for small plaice causing a danger to the stock in the area" can be answered by showing what changes in gear and in the grounds fished by English vessels have taken place.

The principal gear used by English vessels is the trawl, Steam trawlers take about 86 % of the total English North Sea plaice landings and sailing and motor trawlers about 8 %. There has been a considerable alteration in the gear of steam trawlers, since in the main they have adopted the Vigneron-Dahl trawl or its many modifications during the last 6 years. Dr. Bowman (Rapp. et Proc.-Verb. LXXX, 1932) has shown that the V.D. gear takes about 50 % more haddock than the ordinary otter trawl, the size of

ie haddock, however, remaining the same. We do ot know the increased proportion of plaice caught it it must be considerable since the net fishes over much wider area than the otter trawl. In other ords, a more efficient gear is used and consequently ie that is more destructive to young plaice.

Steam trawlers fish over the whole North Sea and iling and motor trawlers in the Southern portion outh of 53°30′ N.) almost exclusively. The total imber of hours' fishing by steam and sailing trawlers is decreased since 1927, while that of motor trawlers is increased:—

Number of hours' fishing.

	1927	1932
eam Trawlers	1,906,821	1,575,726
iling —	416,818	245,572
otor —	11,065	51,211

This has had the effect of reducing the quantity of ice landed from the North Sea:—

	1927	1928	1929	1930	1931	1932
ns landed	22,019	21,245	20,812	19,381	17,984	16,052

These, however, are the landings from the whole rth Sea and the question asked is concerned with destruction of young plaice. In order to see ether the young plaice grounds have been more less heavily fished, the number of hours' fishing the English statistical rectangles near the Conti- ntal coasts by Steam Trawlers and the landings of ice from them have been calculated.

Number of hours' fishing and landings of Plaice (tons) by English Steam Trawlers from Rectangles J3, 4, 5; K5, 6; L6; M6, 7, 8, 9, 10; N6, 7, 8, 9, 10.

Year	Hours' Fishing	Plaice (tons)
1923	110,332	1345
1924	84,244	1267
1925	59,918	983
1926	32,902	490
1927	59,956	866
1928	114,261	2230
1929	97,192	2024
1930	60,047	1102
1931	46,028	845
1932	61,910	818

It will be noticed that the figures vary considerably from year to year, and it must be remembered that since 1928 the V.D. gear has been adopted generally. To appreciate most readily whether the depletion of plaice on these grounds has increased, the periods 1923—1927 and 1928—1932 can be compared:—

Landings of plaice (tons) 1923—1927	4,951
— — — 1928—1932	7,019

Since in these areas the destruction of young plaice is very great, almost invariably more than half the catch is thrown overboard for the most part dead, as they are too small for the market, it is inevitable that more young plaice have been killed uselessly during the past five years than in the earlier period.

In another report on the present condition of the Southern North Sea plaice stock, it has been shown that the plaice fishery is showing signs of uneconomic exploitation. The number of plaice present in the sea is diminishing and the average size of the fish is becoming considerably smaller.

Estimation of the Destruction of "undersized" Plaice by Dutch Motor Vessels during 1932.

By

J. J. Tesch, 's Gravenhage.

At the request of the Danish colleagues in the International Council an attempt has been made to give the widest possible information in connection with the catch of the smallest categories of plaice by Dutch motor vessels.

The material is derived from two sources:

1. weekly measurements of the smallest category of plaice (small III) sold on the market of IJmuiden, from March to February (incl.) 1932—33; these plaice were nearly all caught by motor luggers and motor coast vessels, in two regions: the grounds of Terschelling and of Haaks.
2. estimated quantities of "puf", not fit for human consumption, and sold to fish meal factories etc. from the beginning of April to the middle of July 1932.

I. Measurements of Plaice (small III) at IJmuiden.

Of these fish a basket as sold at the market was measured once a week (with many intervals); sexes were separated and each fish measured to the nearest centimeter below. The total number measured was more than 16000 individuals.

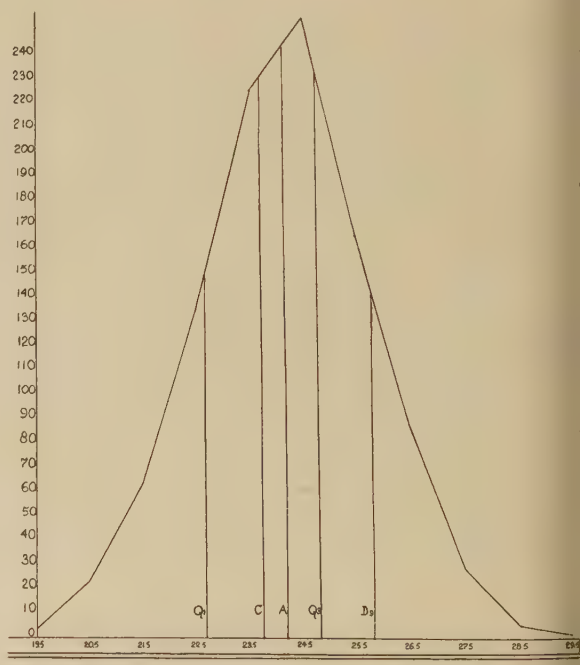
The following tables give particulars of these measurements:

	A Terschelling grounds	B Haaks grounds	A + B
cm.	‰	‰	‰
19.5	3	4	4
20.5	21	25	23
21.5	71	57	64
22.5	159	113	136
23.5	254	196	225
24.5	252	255	254
25.5	137	196	167
26.5	66	112	89
27.5	27	33	30
28.5	7	7	7
29.5	3		1
	1000	998	1000 = 143 kg.

A	= 24.00 cm.	24.33 cm.	24.165 cm.
C	= 23.47 -	23.91 -	23.69 -
Q 1	= 22.47 -	22.76 -	22.60 -
Q 3	= 24.46 -	25.00 -	24.76 -
D 9	= 25.55 -	26.00 -	25.80 -

	Percentage					
	by No.	by weight	by No.	by weight	by No.	by weigh
< 20 cm.	.3	.14	.5	.22	.4	.2
< 22 -	9.5	6.3	8.7	5.0	9.1	5.3
< 25 -	76.1	69.3	65.1	53.7	70.6	63.4

The average weights are taken from Heincke's well known standard weights at each cm. length. The graph here given will elucidate the differen points.



Graph representing 1000 ind. of plaice "small III" at IJmuiden, March 1932—Febr. 1933.

As a 1000 of these plaice have a weight of 143 kg and, in 1932, 2.7 mill. kg. of this lowest category o small plaice were landed in this country, it is eas to calculate that this quantity contains 24 mill individuals. Of these 16,900,000 (= 70.6 %) ar under 25 cm. representing a weight of 1,711,000 kg (= 63.4 %).

II. Landings of small Plaice ("puf") at IJmuiden.

The destruction of young plaice by motor coas vessels ("motorbotters") has for about the last 1

rs caused considerable agitation in Holland. Any luation of the damage done to the fisheries by ging ashore large quantities of these small plaice, en purposedly fished for, was, however, greatly npered by the difficulty, almost impossibility, of ting approximate statistics of these quantities which not sold at the market but handled privately. n a small treatise I estimated the quantity of f" landed at the three principal ports in Holland ing 1924 to be about 2,087,250 kg. It may have n much more, even at that time, but undoubtedly later years this fishery for "puf" has largely eased according to the unanimous opinion of concerned in this trade.

low much it has increased will remain a matter guesswork, but some data for information at least available. These data comprise approximate res of "puf" landings at IJmuiden collected in 2 during some months (spring and beginning of mer) when these landings are not only at their est, but contain a maximum proportion of plaice. quantities landed during this period were esti- ed at 6,935,000 kg.

n order to get a somewhat reliable figure for the le year, as regards young plaice alone, we must in mind that the different months of the yield very variable quantities of "puf" (the er months are in this respect much poorer than r seasons) and, moreover, that the "puf" landings ain a large proportion of dabs. According to my ner investigations in this matter the proportion roughly 35 : 59 by weight and 26 : 71 in number, plaice and dabs respectively, the remaining per- ages having been ascribed to "other fish". On other hand it must be borne in mind that these ner investigations relate to winter months and surely the percentages for plaice are expected e much higher in other seasons, especially in the g, when the landings of "puf" are often emely heavy.

e must, therefore, proceed somewhat arbitrarily even so, it may be assumed with some amount rtainty that the quantity of "puf" at IJmuiden, ning nearly 7 mill. kg. in $3^1/_2$ months, will rise 5 mill. kg. for the whole year. This valuation be rather an under-estimate and it is thus on safe side.

e have arrived at a percentage of plaice in the " of 35 in weight and 26 in number, but only he winter months. For the whole year these n ages may be raised to 40 and 30 respectively. verage length of the plaice in these landings is n, with an average weight of 52 gr.

arrive, then, at the conclusion that in 1932 ,000 kg. plaice ("puf") = about 115,000,000 iduals were landed at IJmuiden.

this port, however, takes about $^1/_3$ of the landings uf" in our country (Helder and Scheveningen in this respect equally important) we must ply again by 3 and get the astounding figure 5 mill. plaice for the whole year.

Compared with the calculated figure of 24 mill. plaice of the trade category "small III" the destruction of a quantity nearly 14.5 times as large, looms ahead of us in an alarming way indeed.

III. Conclusion.

We must, then, conclude that in 1932 an enormous destruction of young plaice has been brought about in this country, amounting to 345 mill. by the most harmful fishery for "puf" and to 17 mill. (included in the category "small III") by the regular fishery, a total quantity of 362 mill. plaice under market value and nearly all of them less than 25 cm. in length.

We know from our former experience that in this "puf" half of the young plaice belong to the III- and a quarter to the IV-group.

The fishery for "puf" in 1932, therefore, largely injured the year classes of 1929 and 1928 and levied a toll of no less than 170 mill. individuals of the 1929-class (III-group) to which must be added a loss of 85 mill. individuals of the 1928-class.

From the recent paper of SCHUBERT, WULFF and BÜCKMANN we learn that the year class 1929 of plaice has been poor, whilst that of 1928, on the other hand, may be estimated to be one of the (rarely occurring) very productive year classes.

The qualification "very poor, poor, normal, rich" depends on the number of individuals of a particular year class surviving the second year of life and entering into the II-group. According to the authors quoted these numbers are: in the case of a very poor year class (like 1930) 200—300 mill. individuals, in that of a poor one (1929) 250—400 mill., for a normal year class (1927) 300—450 mill. and in case of a very rich production (like 1928) 800—1200 mill. — all these figures refer to the German Bight. What, then, is to be expected if a poor year class like 1929 is intensely fished for on the offshore grounds?

If we take the number of the 1929 year class to be 400 mill. individuals in the beginning of the third year of life in 1931, with an average length of 16 cm., we may assume, according to our former investigations, that 16 % or about 60 mill. will be caught in this third year. Many more may get into the cod-end but escape through the mesh, and as also a part of these will perish, we may safely assume a mortality of 60 mill.

The remainder — 340 mill. — will be subject in the next year to a very intense fishery. Half of them — viz. 170 mill. or the same number as was calculated above — will perish from this fishery. By 1933 the year class will be reduced to 170 mill. individuals with an average length of about 21 cm., but again the fishery for "puf" will destroy half of them, leaving at the end of that year 85 mill. at a length of about 23 cm. This greatly diminished stock still being under marketable size, then, will be partly subject to the fishery for "puf", which in the sixth year of life (1934) still levies a toll of 4 % (= about 3 mill.), but the greater part, though,

to the regular fishery which takes them as "small III", so that again a quantity of 17 mill. annually (all under 25 cm.) will be killed.

We must suppose, then, that before entering into real market categories, about 85 % of a particular year class will be destroyed by the fishing alone. The third year of life, especially the fourth and fifth year, are so largely injured by this harmful fishing for "puf" that there is some danger of a particularly poor year class being altogether wiped out before reaching marketable size.

What has been said here may be open to criticism. I am aware that my assumptions do not rest on a perfectly solid foundation. But it may be of interest to have at least an approximate evaluation of the damage done to the plaice fishery at large in this country alone by the most harmful fishing for "puf". With all allowance made for an increase of growth of surviving plaice — this fact cannot compensate for the wanton destruction of plaice of $3^1/_2$—$4^1/_2$ years old which have nearly uselessly availed themselves of the plaice food and have been killed at a size which renders them almost valueless for the market.

Erhebungen über die Anlandung untermassiger Schollen aus der Nordsee in Deutschland.

Von

A. Bückmann, Helgoland.

1. Menge und Grössenzusammensetzung der gelandeten untermassigen Schollen.

Von Fischdampfern werden in Deutschland nur verschwindende Mengen von Nordseeschollen gelandet (nach Lundbeck im Jahre 1929 nur ca. $^1/_2$ Million Stück). Die deutsche Schollenfischerei in der Nordsee liegt vielmehr fast ausschliesslich in den Händen der Hochseekutter. Diese landeten nach Lundbeck's Befunden 1931 ca. 13 Millionen, 1932 ca. 10 Millionen Stück Schollen als Marktware. Von diesen waren nur unerhebliche Mengen kleiner als 22.5 cm. In den von Lundbeck untersuchten Fängen massen:

weniger als	22.0	23.0	24.0	25.0	26.0 cm.
1931 ‰	7	38	125	259	473
1932 ‰	5	27	94	208	381

In den einzelnen Proben wurden folgende Prozentsätze von Schollen unter 23 cm. gefunden:

Prozentsatz unter 23 cm.	0	1	2	3	4	5	6	7	8	9	10 u. mehr
1931 von 51 Proben	17	15	3	1	2	0	2	2	1	2	6
1932 von 58 Proben	30	11	6	2	3	0	1	0	1	0	4

Nur in einzelnen Fällen werden also untermassige Schollen absichtlich in grösserer Zahl mit angelandet (vorwiegend in kleinen Fängen). Meist handelt es sich nur um zufällige Beimengungen. Der Scheidewert zwischen marktfähig und untermassig bei der Sortierung auf See lag 1930—31 etwa bei 24.0 cm., 1932 sogar noch höher.

Aus den angegebenen Zahlen lässt sich berechnen, dass von den Hochseekuttern als Marktware gelandet wurden:

Schollen	unter 22.0 cm.	unter 23.0 cm.
1931	ca. 91 000 Stück	ca. 500 000 Stück
1932	ca. 50 000 „	ca. 270 000 „

Zur Fischmehlbereitung wurden von den deutschen Hochseekuttern 1932 keine kleinen Schollen angelandet. Auch in früheren Jahren haben nur einige wenige Kutter ihre Beifänge an die Fischmehlfabriken abgegeben. Der Umfang dieser Anlandungen ist nicht festgestellt worden.

Über die Anlandungen der Garnelenfischer und den Gehalt des zur Fischmehlbereitung benutzten sogen. »Gammels« an Nutzfischen liegen Untersuchungen der Biologischen Anstalt für das Jahr 1929—30 vor (Schubert-Wulff und Bückmann, in Wiss. Meeresuntersuch. Abt. Helg. Bd. XIX, 1932). In den Anlandungen jenes Jahres (November bis Oktober) waren ca. 65 Millionen kleine Schollen enthalten. Die Längenzusammensetzung von ca. 27 000 Schollen, die bei diesen Untersuchungen gemessen wurden, ist wie folgt:

cm. ...	2—5	6—10	11—15	16—20	21+
‰ ...	266	499	204	28	1

Die gleiche Zusammensetzung der Gesamtanlandung vorausgesetzt, würden von den 65 Millionen ca. 50 Millionen bis 10 cm. gross gewesen sein, und noch nicht 2 Millionen grösser als 16 cm.

Die Scholle ist ein ganz nebensächlicher Massenstandteil der Fänge und wird nur zufällig neben inen Garnelen etc. mitgefangen. Die Zahl der verhteten Schollen ist unter diesen Umständen nicht r von der Stärke der Fischerei, sondern auch von r Häufigkeit der jeweils betroffenen Jahresklassen r Scholle (0- und I-Gruppe) abhängig. Im Unterchungsjahr handelte es sich zumeist um die Jahrnge 1929 und 1930, von denen der erste mittelstark, r zweite arm war. Aber auch Jahrgang 1931 war n, und im Jahre 1932 ist der Umfang der Gammellandungen zurückgegangen, sodass die Zahl der rnichteten Schollen in den folgenden Jahren schwerh grösser gewesen sein wird als 1930.

Wie verhält sich die Menge der untermassig vernichteten Schollen zu der Grösse der hollenbevölkerung gleicher Längenstufen im Meer?

Eine solche Frage ist ausserordentlich schwer zu ntworten, da wir ein sicheres Mittel zur Bestimng der Grösse des Bestandes nicht haben.

Wir können versuchen, ausgehend von dem Durchmittsfang je Zeiteinheit unserer Forschungsfahrge auf den recht eingehend untersuchten Jungschgründen die Grösse der Bevölkerung in diesen ieten zu berechnen, wenn wir den Fangkoeffiten des Netzes kennen. Wir verfügen nur über noch sehr unsichere Bestimmung dieses Wertes ch Heincke, wonach der Fangkoeffizient zwischen und 0.3 liegt, d. h. es werden ein Fünftel bis ein tel der auf der befischten Fläche befindlichen llen gefangen. Neue und ausgedehntere Unterungen auf diesem Gebiet sind dringend notwendig! hnen wir mit dem von Heincke angegebenen ffizienten, so können wir die Grösse der Scholbevölkerung in dem von uns genauer unterten Teil der Deutschen Bucht zwischen den enlinien von 10 und 40 m., zwischen 6° ö. L. und 0′ n. Br. näherungsweise berechnen. Grösse und ammensetzung schwanken von Jahr zu Jahr unter Einfluss der Fluktuationen etc.

ge in cm.:	bis 10	11-15	16-20	21-22.5	22.5-25	26+
1931 . . .	72	565	400	64	87	43
lkzahl in	bis	bis	bis	bis	bis	bis
onen . . .	107	847	600	96	131	64
l 1932 . .	18	295	553	85	87	23
lkzahl in	bis	bis	bis	bis	bis	bis
onen . . .	27	442	829	127	131	35

der Fangkoeffizient niedriger als angenommen, en sich diese Zahlen erhöhen, ist er grösser, vern. Zu bemerken ist ferner, dass die Schollen der uppe, die um diese Jahreszeit meist weniger als n. gross sind, im Frühjahr erst zum kleineren aus dem Wattenmeer auf die Hochsee ausgewans sind. Im übrigen aber halten sich die unterigen Schollen der südöstlichen Nordsee im April —Mai fast ausschliesslich innerhalb unseres Untersuchungsgebietes auf.

Das kleine von uns untersuchte Teilgebiet der Nordsee umfasst das wichtigste Jungschollengebiet. Das Gebiet vor der holländischen Küste ist 1931 und 1932 zur gleichen Jahreszeit und in ähnlicher Weise von Dr. Tesch untersucht worden, der mir freundlicherweise Einblick in sein Material gewährte. Aus verschiedenen Gründen ist es bedenklich, das oben angewendete Berechnungsverfahren ohne weiteres auf das holländische Material zu übertragen. Doch kann man mit Sicherheit erkennen, dass in dem Gebiet vor der holländischen Küste, das die Deutsche Bucht an Ausdehnung übertrifft, viel weniger untermassige Schollen vorhanden sind, wahrscheinlich weniger als halb soviel. An marktfähigen Schollen dagegen ist jenes Gebiet reicher, vor allem in dem nördlichen, an die Deutsche Bucht angrenzenden Teil. Ich bin der Überzeugung, dass dies auf den Zuzug heranwachsender Schollen aus der Deutschen Bucht zurückzuführen ist.

Es ist möglich, dass die Deutsche Bucht auf Grund der natürlichen Bedingungen das reichere Jungschollengebiet ist. Doch liegt die Annahme nahe, dass die intensive Befischung des Gebiets vor der holländischen Küste mit den engmaschigen Trawls der Dampfer und Kutter den Jungschollenbestand dort dezimiert hat, während sich in der Deutschen Bucht, wo vornehmlich mit Wade und weitmaschigen Trawls gefischt wurde, eine dichte Bevölkerung hielt. (In neuester Zeit erscheinen leider unrationell fischende Fahrzeuge wieder in grösserer Zahl in der Deutschen Bucht.)

Die Menge der Schollen des ersten und zweiten Lebensjahres, die im Wattenmeer der Befischung durch Garnelenfischer unterliegen, kann nicht direkt geschätzt werden. Erst die Schollen, die das zweite Jahr überlebt haben und auf die Hochsee ausgewandert sind, können wir bei unseren Untersuchungen in repräsentativer Weise erfassen. Für das Gebiet der Deutschen Bucht gelangen wir dann zu folgenden Zahlen: Ein armer Jahrgang (wie 1930) umfasst 200—300 Millionen, ein mittelstarker (1927) 300—450 Millionen, ein reicher Jahrgang (1928) 800—1200 Millionen Stück. Im ersten und zu Beginn des zweiten Lebensjahres müssen die betr. Jahrgänge natürlich noch stärker gewesen sein, weil ihre Zahl in der Zwischenzeit durch die natürliche Zehrung verringert worden ist. Trotzdem aber ist die Vernichtung von 65 Millionen kleiner Schollen durch die deutsche Garnelenfischerei nicht von vornherein als bedeutungslos anzusehen. Es ist sehr wohl möglich, dass dies die Vernichtung von etwa 10 % der an den deutschen Küsten aufwachsenden Schollen bedeutet.

Selbstverständlich dürfen die hier genannten Zahlen nicht den geringsten Anspruch auf Sicherheit machen. Wenn diese Schätzungen vorgenommen werden, so geschieht es in der Überzeugung, dass Schätzungen auf unsicherer Grundlage, wenn man sich ihrer Mängel stets bewusst bleibt, immer noch besser sind als ganz vage Vermutungen. Selbst wenn unsere Zahlen

wesentliche Fehler enthalten, so beweisen sie doch, dass die Menge der vorhandenen untermassigen Schollen keineswegs unbegrenzt ist und dass die Vernichtung von hunderten von Millionen kleiner Schollen durch die Fischerei sehr wohl geeignet ist, den Nachwuchs marktfähiger Schollen zu beeinträchtigen.

3. Schätzung der Ertragsverbesserung nach Gewicht und Wert, die durch Einführung eines Mindestmasses von 22.5 cm. erzielt werden würde.

Der Zweck des Mindestmasses ist die Einschränkung der Vernichtung untermassiger Fische. Die Theorie des »Thinning out«, die besagt, dass man von einem künstlich gelichteten Bestande infolge der Verbesserung des Wachstums höhere Erträge zu erwarten hätte, kann für die südliche Nordsee als widerlegt gelten. Denn selbst wenn man die Wachstumsverbesserung in vollem Umfang einkalkuliert, sind die Erträge aus einem Bestande, in dem die Untermassigen geschont werden, nach meinen Berechnungen doch besser als die aus einem künstlich gelichteten (Bückmann, Rapp. et Proc.-Verb. Vol. LXXX, 1932). Dies gilt wenigstens für die grösseren untermassigen Fische, die von der Hochseefischerei mitgefangen werden. Für die kleinsten Stadien, die der Garnelenfischerei im Wattenmeer zum Opfer fallen, lässt es sich nicht nachweisen, dass ihre Vernichtung einen Verlust, ihre Schonung einen Gewinn für die Hochseefischerei bedeutet. Der Schutz der grösseren untermassigen Schollen dagegen ist erwünscht und das Mindestmass ist ein wirksames Mittel zu diesem Zweck.

Bei der Schollenfischerei werden stets, je nach der Art des Geräts mehr oder weniger, untermassige Fische mitgefangen und — wenigstens z. T. — vernichtet. Früher und in den meisten Fällen auch jetzt noch werden die mitgefangenen untermassigen Fische lebend oder tot wieder ins Meer geworfen. Das Mindestmass ändert daran nur dann etwas, wenn durch ein Anlandungsverbot der Verkauf von wesentlichen Teilen des Fanges verhindert wird, sodass die Befischung von Jungfischgründen und die Verwendung engmaschiger Netze unrentabel wird. Da man aber das Mindestmass aus praktischen Gründen nicht allzu hoch wählen kann, so wird die Menge der am Markt als menschliche Nahrung verkäuflichen Schollen unterhalb des gesetzlichen Mindestmasses stets gering sein. Bei früheren Diskussionen wurde daher mit Recht Zweifel daran erhoben, ob dieser Teil des Fanges so gross wäre, dass sich an dem Betrieb der Fischerei irgend etwas ändern würde. Das ist aber ganz anders geworden, seit es in manchen Hochseefischereibetrieben üblich geworden ist, kleine, für den Markt unbrauchbare Fische zur Fischmehlbereitung mit anzubringen. Dies schädliche Verfahren kann durch ein Mindestmass unterbunden werden. Damit wäre dann eine wirksame Schonung der untermassigen Schollen ohne Zweifel verknüpft.

Jetzt werden die gefangenen Schollen von manche Fahrzeugen sämtlich gelandet und gehen dem Bestande verloren. Würden die Beifänge wie früher im Wasser zurückgeworfen, so würde ein mehr oder minder grosser Teil der kleinen Schollen am Leben bleiben, vor allem bei der Kutterfischerei und bei kühlem Wetter.

Jetzt machen die Nebeneinnahmen aus dem Verkauf der Beifänge das Fischen auf küstennahen, jungfischreichen Gründen möglich, auf denen der Fang von Marktfischen allein zu gering wäre. Das Mindestmass würde das Fischen an solchen Orten verhindern. Ganz unmöglich würde es sein, dass die Boote ausschliesslich zum Fang von »Gammel« oder »Puf« ausfahren, wie es jetzt in Holland und Belgien gelegentlich geschieht. Endlich würde der Anreiz zur Verwendung sehr engmaschiger Netze wegfallen. So würden viele untermassige Schollen teils lebend wieder ins Meer gelangen, teils garnicht gefangen werden, und der Ertrag der Fischerei würde dadurch sicherlich verbessert werden.

Die Grösse dieser Verbesserung des Ertrages aber können wir noch nicht voraussagen. Es ist nicht ohne Weiteres zu berechnen, wieviel Schollen infolge der Einführung des Mindestmasses geschont werden würden. Auch ist unsere Kenntnis über die Frage unzureichend, wie diese Schonung und Vermehrung der Bevölkerung auf die Wachstumsgeschwindigkeit einwirken würde. Diese Beziehungen müssen weiterhin untersucht und durch Experiment aufgehellt werden. Indessen braucht die endgültige Klärung dieser schwierigen Fragen keineswegs abgewartet zu werden: Es ist über allen Zweifel erhaben, dass die Einführung eines Mindestmasses eine Schonung untermassiger Fische und diese wieder eine Verbesserung des Ertrages der Fischerei im Gefolge ha

4. Welcher Verlust an Fangmenge und Wert würde bei Einführung des Mindestmasses entstehen?

Für die deutsche Hochseefischerei würde kein merkbarer Verlust entstehen, da untermassige Schollen als Marktware nur in verschwindender Menge und zur Fischmehlbereitung garnicht angebracht werden.

Bei der Garnelenfischerei ist die Scholle ein unwesentlicher Beifang. Rechnet man mit einem Durchschnittsgewicht von 10 gr. je Stück, so würde das Gewicht der 1929—30 im Gammel angelandeten Schollen nur etwa 13 000 Zentner oder noch nicht 5 % der Gammelanlandungen ausgemacht haben.

Die Schwierigkeit liegt nicht darin, dass die Fischer auf die Anlandung der mitgefangenen Schollen nicht verzichten könnten, sondern darin, dass man die Schollen nicht aus dem »Gammel« entfernen kann. Stellenweise werden allerdings die grösseren Fische und Evertebraten aus den Fängen ausgelesen oder ausgesiebt und gesondert gelandet. Dieser sogenannte »Fischgammel« machte 1929—30 nur 5.7 % des Wertes, 9.4 % des Gewichts der Gammelanlandung

s, enthielt aber 23.3 % der vernichteten Schollen, d zwar gerade vorwiegend die grösseren, deren Ver-chtung vielleicht bereits schädlich ist. Danach neint zunächst ein Verbot der Anlandung von schgammel eine Verminderung der schädlichen ngfischvernichtung bewirken zu können. Es ist doch zu bedenken, dass an den meisten Orten eine ussonderung des Fischgammels nicht stattfindet, ndern dass die ganzen Fänge, z. T. sogar ohne Aus-nderung der Speisegarnelen angebracht werden. Ein rbot der Anlandung von Fischgammel würde daher hl nur dazu führen, dass dies Verfahren überall genommen würde. Ein allgemeines Verbot der Gam-lanlandung durch die Garnelenfischer kommt nicht rage. Dagegen spricht einmal die Erwägung, dass e Schädlichkeit der Vernichtung ganz junger Schol-n nicht nachgewiesen werden kann, zum andern die sse wirtschaftliche Bedeutung der Gammelfischerei. e Existenz der Fischer beruht z. T., an manchen Orten vorwiegend, auf dem Erlös der Gammel-anlandungen. 1929—30 war der Wert dieser An-landungen mit 813 000 Rm. höher als der der deut-schen Schollenfischerei in der Nordsee.

Ausnahmebestimmungen für die Garnelen-fischerei sind also bei Einführung des Mindest-masses notwendig. Am zweckmässigsten ist es, eine untere Grenze für das Anlandeverbot festzu-setzen, sodass die Anlandung der kleinsten Schollen, die man nicht aus dem Gammel entfernen kann, zulässig ist, während die Anlandung der grösseren und älteren untermassigen Schollen verhindert wird. Die untere Grenze des Anlandeverbots kann auf 13.0 cm. festgesetzt werden. Dadurch würde der Schutz aller untermassiger Schollen auf der Hochsee und der grösseren Individuen im Wattenmeer gewähr-leistet werden. Unter diesem Umständen würde das Mindestmass keinen fühlbaren Einnahme-ausfall für die deutsche Fischerei bedingen.

Zusammenfassung.

1. Von der Hochseefischerei wurden aus der Nordsee Deutschland gelandet i. J. 1932 als Marktware 270 000 Stück Schollen unter 23 cm.; zur Fisch-hlbereitung keine Schollen.
In den Beifängen der Garnelenfischer wurden zur chmehlbereitung gelandet i. J. 1930 ca. 65 Mil-nen kleine Schollen.

2. Die Bevölkerung von Jungschollen unter 22.5 cm. ier Deutschen Bucht (ohne Wattenmeer) kann auf 0 bis 1600 Millionen Stück geschätzt werden. Die tsche Bucht ist das reichste Jungschollengebiet. Gebiet vor der holländischen Küste leben wahr-einlich kaum halb soviel Jungschollen. Trotz grossen Unsicherheit dieser Schätzungen kann die Vernichtung von einigen 100 Millionen ermassiger Schollen durch die Fischerei unter keinen Umständen als unerheblich angesehen werden.

3. Die Schonung besonders der grösseren unter-massigen Schollen muss zu einer Verbesserung des Fischereiertrages führen. Das Mindestmass ist ein geeignetes Mittel, eine solche Schonung zu bewirken, da es die Anlandung untermassiger Schollen zur Fischmehlbereitung verhindert. Der Umfang der da-durch bewirkten Verbesserung der Erträge kann noch nicht abgeschätzt werden.

4. Die Einführung des Mindestmasses würde für die deutsche Hochseefischerei keinen merklichen Ein-nahmeausfall bringen. Für die Garnelenfischerei müsste die Anlandung der kleinsten Schollen unter 13.0 cm. zugelassen werden, da diese nicht aus den Beifängen entfernt werden können.

The Distribution of Phosphate and Nitrate in the North Sea in May 1932.

By

Helge Thomsen, Copenhagen.

From April 29 to June 10 the R.S. "Dana" carried out fishery investigations in the North Sea under the leadership of Professor Johs. Schmidt. In addition to the fishery investigations, hydrographic investigations were made by the writer at 47 stations situated as shown on the chart in fig. 1. These investigations consisted of determinations of temperature, salinity, and phosphate and nitrate content at various depths from the surface to the bottom.

For the colorimetric determination of the phosphate content, according to the method of Atkins (1) glass tubes, 30 cm. long with a plane ground bottom, were employed in which the samples of sea-water were directly compared with standard solutions of $Na_2HPO_4\ 2H_2O$ (after Sørensen) in distilled water; this comparison was made by mag. sc. A. F. Bruun. The results are expressed in mg. P_2O_5 per cubic metre of sea-water; the accuracy of the colorimetric determination may presumably be estimated at $\pm$ 5 mg. P_2O_5/m^3.

The nitrate determinations were made according to Harvey's method (2) with Denigés' reagent; a large portion of this was made in the Hydrographic Laboratory at Copenhagen, about the middle of April, and it remained colourless until the last of it was used at the beginning of August. The determination was made with 7 $cm.^3$ of sea-water by the addition of the same volume of reagent. The colorimetric determination was made by means of a Sund's (3) colorimeter (earlier model) in which the samples of sea-water were directly compared with standard solutions of $NaNO_3$ in nitrate-free sea-water, which was treated in exactly the same way as the sea-water samples. The nitrate contents are given in mg. nitrate nitrogen per cubic metre of sea-water. The accuracy of the colorimetric determination is estimated at $\pm$ 5 mg./$m.^3$ for the larger, and at somewhat less for the smaller values.

The material collected consists in 213 nitrate determinations and 190 phosphate determinations. In order to convey an idea of the horizontal and vertical distribution of the nutrient salts in May 1932 the quantities of nitrate and phosphate found at depths of 0, 25, 50, and 75 m. are given in the charts in figs. 1—8. At some of the stations there are no observations from a depth of 25 m., but in those cases the mean values of the contents at 20 and 30 m. have been used.

A consideration of the charts in figs. 1 and 2 will show that in May no appreciable quantities of nitrate occurred, except at some few stations, and only small amounts of phosphate (averaging 7.7 mg./$m.^3$). This agrees with observations by Atkins (4), Harvey (5), and Cooper (6) in the English Channel, and by Braarud and Klem (7) in the coastal waters of Norway (at about 63° N. Lat.). At both places it was found that the nutrient salts accumulated in the course of the winter are almost entirely consumed during the spring outburst of plankton — especially in April — so as to leave only quite small quantities of phosphate and nitrate in the surface layer.

The time at which the phosphate and nitrate minimum in the North Sea occurs is likely to vary a little in the different years, as is the case in the English Channel. In 1932 the minimum had obviously been attained before the end of April, all the nitrate at the surface being then consumed, and only slight quantities of phosphate being left. In this connection it must, however, be mentioned that the observations from the "Dana" took place in two periods. From April 29th to May 1st, observations were made at 5 stations along the coast of Jutland from the Skaw to Esbjerg, and not until May 10th the observations were continued in the rest of the North Sea. At the first 5 stations the nitrate minimum had, however already occurred, and it is probable that it had also occurred at the rest of the stations at this time.

From 1931 phosphate determinations by Kalle (8) from the south-eastern part of the North Sea are available. From the 3rd to the 9th of May work was

rried on (in the R.F.D. "Poseidon") in an area rth of Heligoland up to the latitude of Fanø 5°25′), and an average phosphate content of about mg. P_2O_5/m.³ was found[1]). From May 9th to May th, in an area south-west of Heligoland, an average about 10 mg./m.³ was found. This difference in the osphate content might be due to the different uation of the two areas, but it can hardly be ubted that the difference in time has been decisive the phosphate content, the summer minimum ving evidently occurred during the cruise. On May l the average of all surface observations on that y was found to be about 40 mg./m.³, and the fol- ving days show a fairly even decrease in the phos- ate content until May 14th, when it averaged less n 9 mg./m.³, that is to say, it was of the same ler of magnitude as the phosphate contents found the "Dana" in May 1932.

Thus KALLE's observations would seem to indicate t the minimum in the North Sea occurred some- at later in 1931 than in 1932, since, as KALLE s, in the period from May 3rd to May 9th, 1931, are "kurz vor dem in jedem Frühjahr stattfindenden osphatminimum", while this must be said to have n reached at the end of the cruise (May 11th—14th) en the quantity of phosphate was about 8—9 mg. O_5/m.³, whereas the minimum had already been ained on May 1st, in 1932.

Though the nitrate amount had been entirely con- ned in the surface layer in May, there were still preciable quantities of phosphate compared with nitrate contents, a circumstance which must, no ubt, be explained by the spring outburst of plankton ng stopped owing to lack of nitrate before the ire amount of phosphate had been consumed. Only dually as nitrate is produced again a further con- ption of phosphate can take place, and that such ther decrease in the quantity of phosphate is bable would seem to be indicated by SEIWELL's (9) ervations. In July 1928, when the "Carnegie" ssed the North Sea, the last-named author found average of 2.5 mg. P_2O_5/m.³ in the surface layer, against the above-mentioned 7.7 mg./m.³ found May.

t a depth of 25 m. (figs. 3 and 4), as in the sur- e layer, no nitrate or a very inconsiderable nitrate ntent was found in May 1932, except in the area the coast of Scotland and the northern part of gland. The phosphate contents were somewhat her than at the surface (average: 12.1 mg./m.³); the horizontal distribution hardly presents as ple features as the distribution of nitrate, though highest phosphate contents were likewise found he north-western and western part of the area estigated.

t a depth of 50 m. the horizontal distribution of ate which was suggested at 25 m. is fairly con- uous. No nitrate is found near the 50-metre curve, but in the deeper northern and western parts of the North Sea quantities of up to 75 mg./m.³ occur. The same general picture is presented by the phosphate distribution, the lowest values (10—15) occurring near the 50-metre curve and the highest (up to 60 mg./m.³) to the north and west.

At 75 m. (figs. 7 and 8) the observation material is considerably smaller than at 50 m. owing to the bathymetric conditions; nevertheless, the horizontal distribution of nitrate and phosphate shows essentially the same features as at 50 m. The nitrate content varies from 0—10 mg./m.³ in the southern part, to 60 mg./m.³ in the north-western part. At the station near the Scaw there are 75 mg./m.³, but the observations at this station were made as early as April 29th, and this value is, therefore, hardly directly comparable with the rest. The phosphate content likewise increases from 10—25 mg./m.³ in the south to 35—60 mg./m.³ in the north.

Thus the available observations indicate that at the average the content of nutrient salts is highest in the north-western and western parts of the investigated area of the North Sea. It would, then, seem natural to suppose that the salt water flowing into the North Sea from the Atlantic to the northward of the British Isles, chiefly between the Orkneys and the Shetlands, carries considerable quantities of phosphate and nitrate into the North Sea. This supposition is supported by the fact that the water in Pentland Firth contains fairly large amounts of nitrate, and this must also be supposed to be the case with the water flowing into the North Sea between the Orkneys and the Shetlands. JACOBSEN and JENSEN (10) have shown that an intensive mixing of the surface layer and the deeper layers takes place on the Orkney-Shetland shelf, and this must cause nutrient salts to be conveyed to the surface layer from the deeper layers, which, as is well known, contain large quantities of these salts.

If the larger content of nutrient salts in the north-western part of the North Sea is supposed to be due to the influx from the Atlantic, it must be expected, if the consumption of nutrient salts be disregarded, that a high positive correlation between the content of nutrient salts and the salinity will be present, because the saltest water is the purest Atlantic water.

By way of experiment, the content of respectively nitrate and phosphate has been correlated with the salinity, and the computed values of the coefficient of correlation r are given in the Table below, together with the standard deviation df or σ_r.

Depth	Nitrate		Phosphate	
	r	σ_r	r	σ_r
25	.003	0.17	0.32	0.16
50	0.29	0.21	0.40	0.21
75	0.42	0.25	0.54	0.22

[1]) KALLE gives the phosphate content in mg. P/m.³; purposes of comparison it has here been converted mg. P_2O_5/m.³.

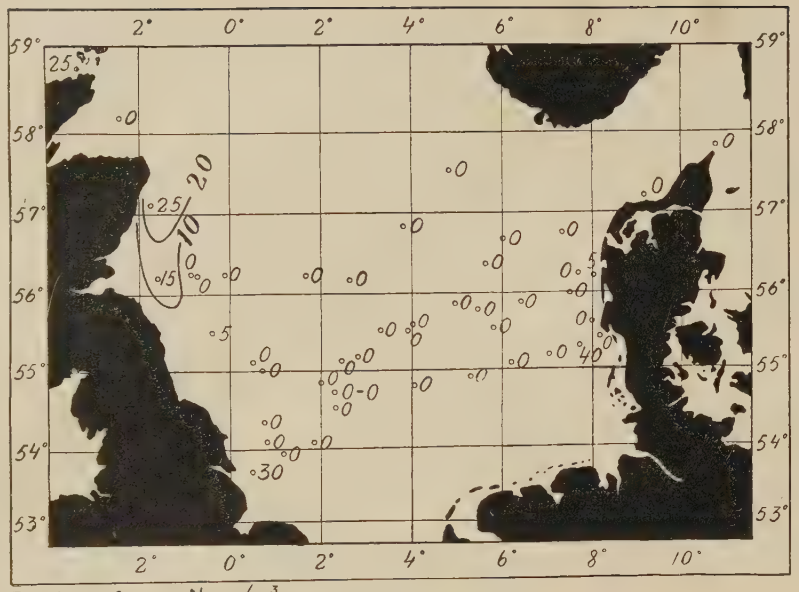


Fig. 1 0 m. N_{NO_3}/m^3

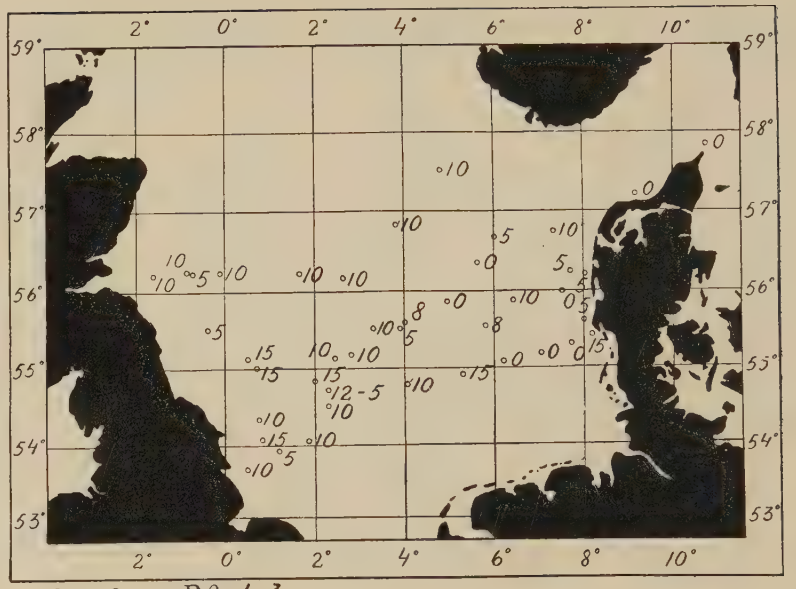
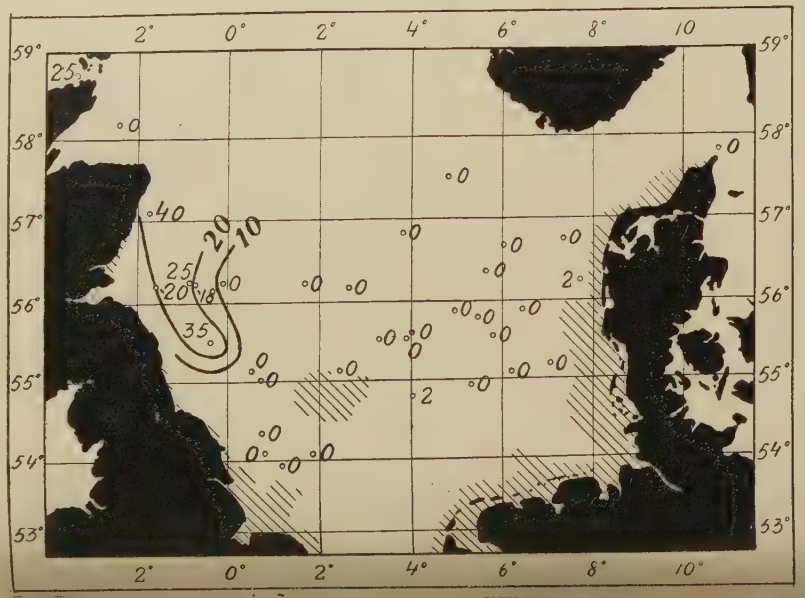


Fig. 2. 0 m. P_2O_5/m^3



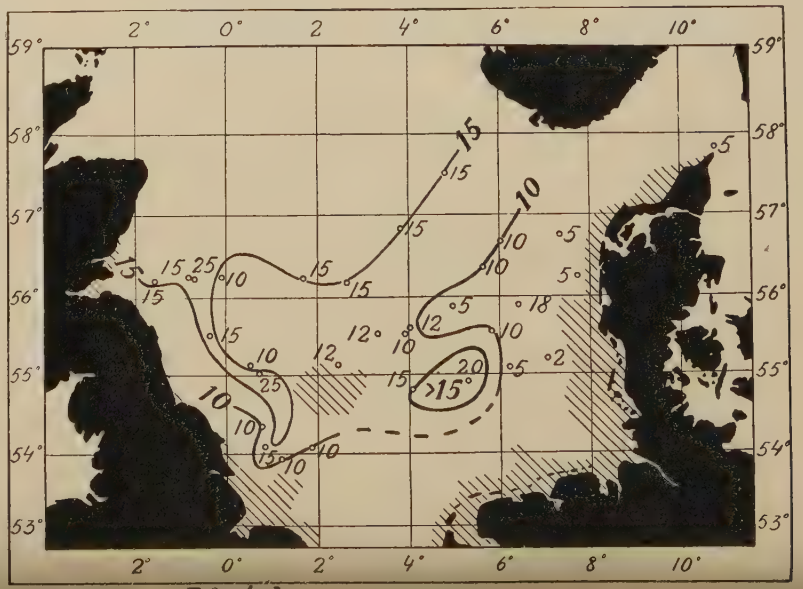


Fig. 4 25 m. P_2O_5/m^3

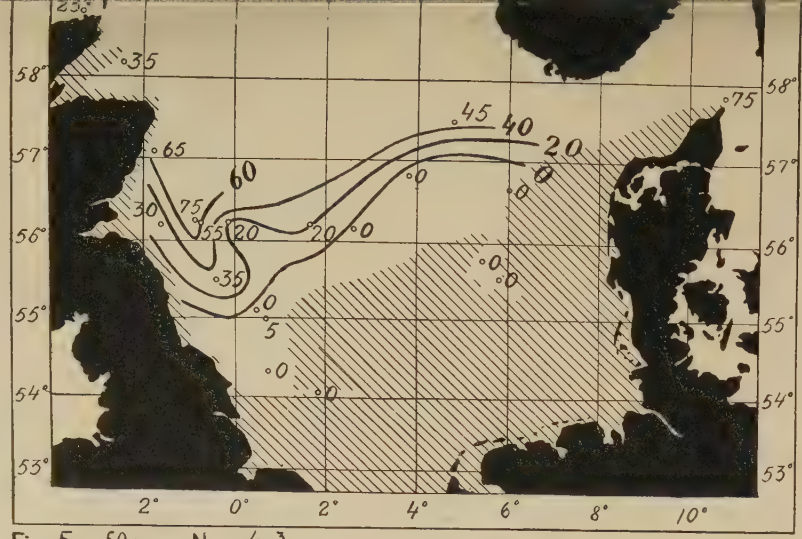


Fig. 5 50 m. N_{NO_3}/m^3

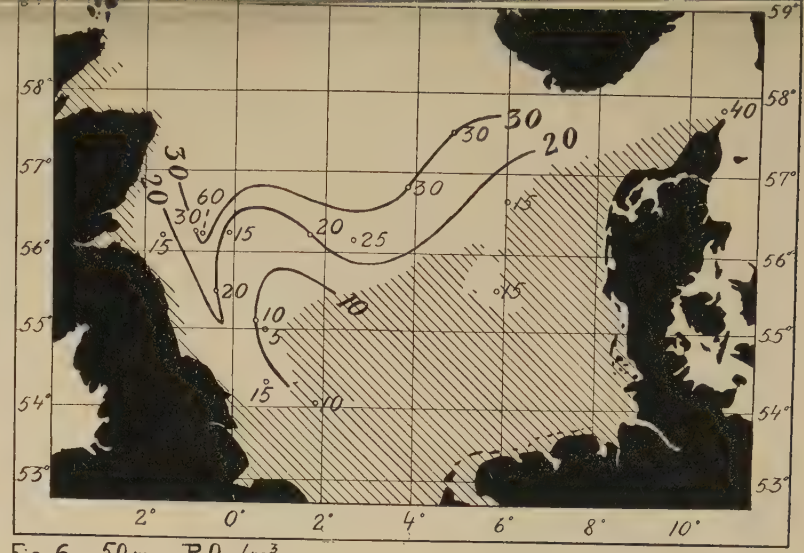


Fig. 6. 50 m. P_2O_5/m^3

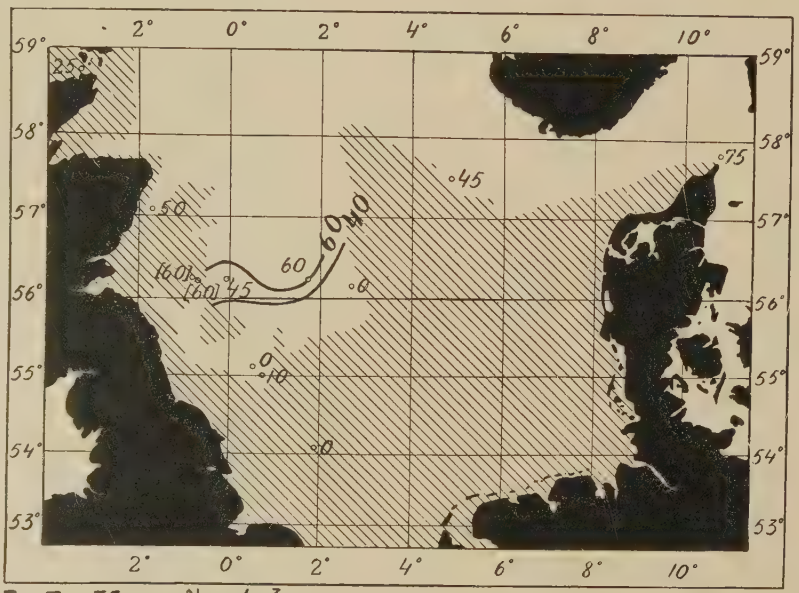


Fig 7. 75 m. N_{NO_3}/m^3

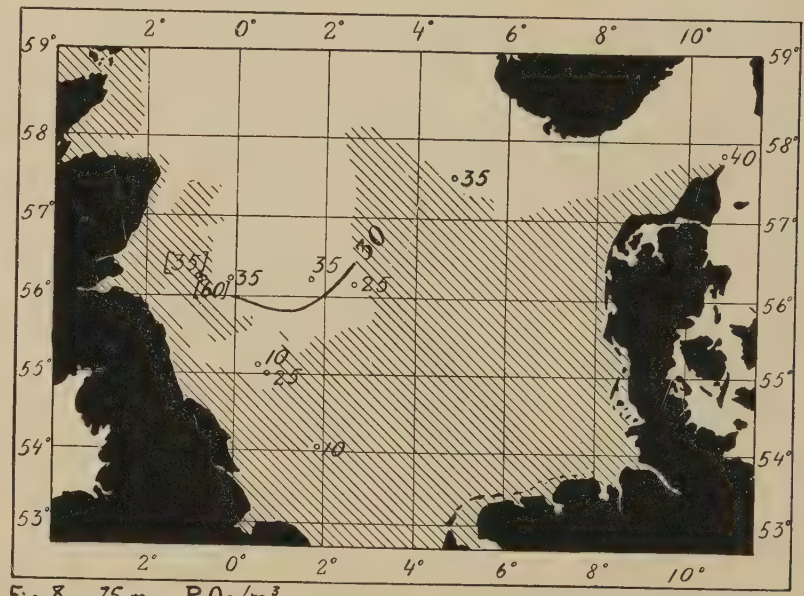


Fig. 8 75 m. P_2O_5/m^3

It will be seen that the coefficients of correlation are all positive, though small, and at most twice the standard deviation; but, as is well known, the presupposition that no consumption of nutrient salts takes place does not correspond with the facts. But the closer this presupposition is fulfilled, the better must the correlation be expected to be found, if nutrient salts are conveyed into the North Sea with the salt Atlantic water. At increasing depths the consumption decreases, hence the coefficient of cor relation should be expected to increase with th depth. A glance at the Table will show that thi is precisely what takes place. Hence, the fact tha the coefficients of correlation are not larger is du to the consumption rather than to a lack of cor respondance between the influx of salt Atlantic wate and the amount of nutrient salts in the North Sea

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Observations on the Penetration of Daylight into Mid-Atlantic and Coastal Waters.

By George L. Clarke, Woods Hole.

Abstract.

Measurements of the penetration of daylight into the sea were made in the mid-Atlantic, in the Gulf of Maine, and in Woods Hole harbor, using the photo-electric method described by Poole and Atkins (1931). A four-conductor insulated cable and an electrically operated internal shutter have been added to the No. 1 Sea Photometer. Each of our photometers contains a potassium sensitized photo-electric cell (two are vacuum cells, one is gas-filled). All three photometers exhibit essentially the same spectral sensitivity. For purposes of standardization the range of sensitivity is considered to extend from 3460 A° to 5260 A° with a maximum at 4360 A° (see Fig. 2). The photometers have been standardized against a 1000-watt Mazda lamp, the value of the irradiation from which was limited to that occurring within the spectral range of the photometers. The results of standardization are presented in Table I. The range of irradiation which can be measured by our photometers is approximately 50,000 μW to 1 μW (1 micro-watt equals about 3 meter-candles as used by Poole and Atkins).

The present measurements are subject to certain errors common to all investigators of this type. A particular difficulty encountered was variability in the emission of the photo-electric cells. In view of the precautions taken — such as checking with a portable test lamp — these observations are believed to be at least as accurate as former ones. Measurements in each vertical series were ordinarily made every ten meters. The value for each depth is the average of at least 3 readings. *(Continued on page 49).*

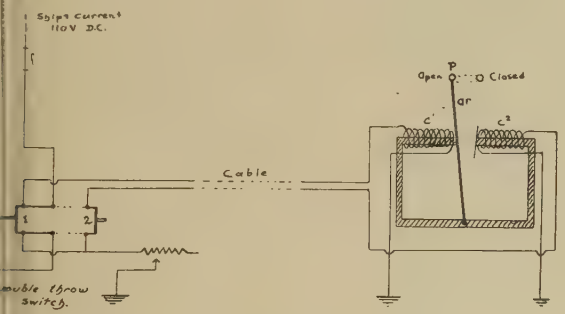

Fig. 1. Diagram of the connections of the electrically operated shutter.
1) Position of switch to open shutter.
2) Position of switch to close shutter. Except for the moments of operating the shutter, the switch is left with contacts broken in the vertical position.
A ammeter; *ar*, armature; c_1, c_2, coils of electromagnet; *ff*, 1-ampere fuses; *P*, post attached to leaves of shutter.

Table 1.

Standardization of Photometers.

Irradiation necessary to produce photo-electric current of 1 micro-ampere at an anode potential of 60 to 63 volts.

Photometer	Carbon arc used as a standard *)	1000-watt Mazda lamp used as a standard		Photo-electric emission produced by test lamp (used to check for changes in sensitivity at sea)
	Irradiation extending over visible range	Irradiation extending over visible range	Irradiation within range: 3460 A°—5260 A°	
	Meter-candles	Meter-candles	Micro-watts/cm.² ***)	μa
Deck	370	1610	135	4.4
No. 1 Sea (1931)	870	2080	175	—
No. 1 Sea (1932)	—	3760	315	2.1
No. 2 Sea.....	232*)	750**)	63*)	—

*) Values given by Poole and Atkins (1931).
**) Values obtained immediately after glowing the cell for one second (see Poole and Atkins, 1931).
***) 1 micro-watt/cm.² = 10 ergs/cm.²/sec. = .0000143 gr. cal./cm.²/min.

Note: The decreased sensitivity of No. 1 as used in 1932 was caused by the greater distance between the photo-electric cell and the photometer window. This change in position was necessary in order to make room for the new internal shutter.

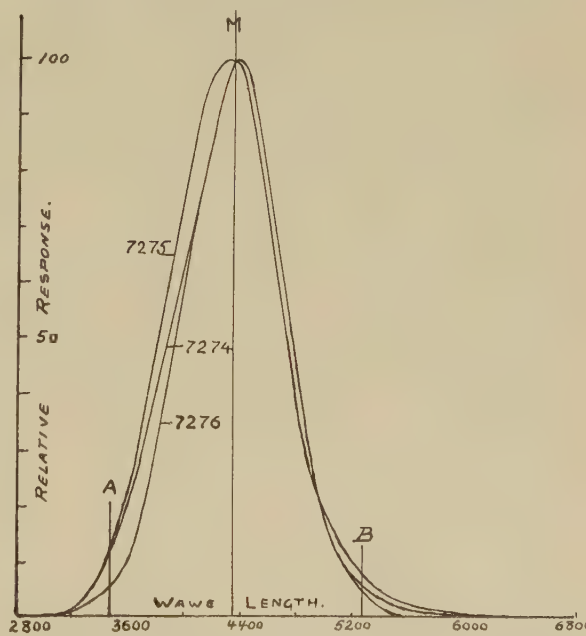

Fig. 2. Comparison of Spectral Sensitivities of Photometer.
No. 7276 — vacuum potassium hydride cell — Deck photometer.
No. 7275 — — — — - — No. 1 Sea Photometer.
No. 7274 — Gas-filled — — - — No. 2 - —
Each curve represents the relative response to an equal energy spectrum of the combined photo-electric cell and its diffusing disc of opal glass. For purposes of standardization the sensitivities are considered limited to the range between *A* and *B*, which are 900 *A*° above and below *M*, the point of average maximum sensitivity.
A = 3460 *A*° *B* = 5260 *A*° *M* = 4360 *A*°

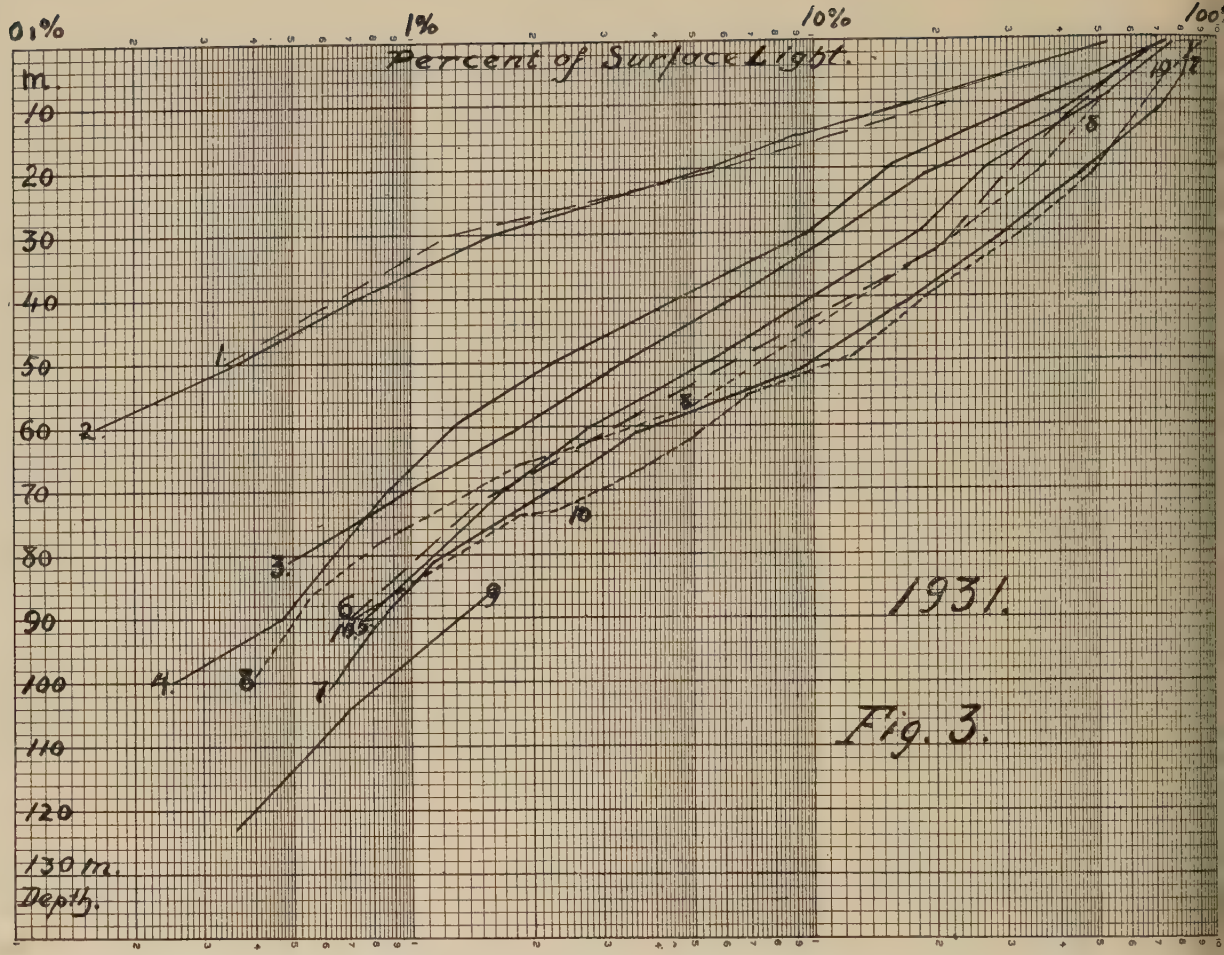

Fig. 3. Relation between depth and irradiation expressed as a percentage of the light just over the surface (logarithmic scale). The series shown (1 to 10) were made in a line running south on Longitude 30° W. The figure at the end of each curve designates the Series number of that curve. The broken lines are merely to aid in distinguishing individual curves from each other in cases where they cross.

Table II. Summary of 1931 Observations.

Series	Station	Lat. N.	Long. W.	Date 1931	Local sun time (24-hour scale)	Average altitude of sun	Average transmissive exponent over depth studied k	Depth at which irradiation is reduced to 1% Meters	Range of irradiation on deck during series[1]) Microwatts/cm.²	Sea (Douglas Sea Scale)	Sky
1	1002	52°17′	29°46′	July 26	1133—1233	57°	0.10	34	16,000—37,000	Moderate	Clear
2	1005	51°17′	30°03′	27	1235—1400	46°	0.10	36	9,000—18,000	—	Overcast
3	1007	50°09′	29°57′	28	1205—1330	50°	0.061	70	13,000—16,000	—	—
4	1010	48°27′	29°58′	29	1130—1245	60°	0.058	66	18,000—38,000	—	Few clouds
5	1013	47°04′	29°59′	30	1115—1205	58°	0.051	83	10,000—53,000	—	Many clouds
6	1016	44°59′	30°08′	31	1110—1215	60°	0.052	81	9,000—24,000	Rough	— —
7	1019	43°13′	30°10′	Aug. 1	1100—1300	65°	0.049	85	11,000—42,000	Slight	Few clouds
8	1023	41°45′	30°33′	2	1103—1208	61°	0.055	75	37,000—38,000	Smooth	Clear
9	1029	38°13′	31°39′	4	1253—1353	55°	0.044	96	28,000—35,000	Moderate	Few clouds
10	1033	37°27′	31°44′	6	1223—1453	54°	0.053	84	11,000—37,000	Slight	— —
11	1038	36°56′	44°52′	12	1545—1745	27°	0.046	89	4,000—19,000	Calm	— —
12	1041	36°55′	52°41′	15	1055—1230	64°	0.031	146	22,000—36,000	Smooth	Clear
13	1053	43°27′	67°39′	24	1010—1120	49°	0.12	32	6,000— 8,000	Rough	Overcast

[1]) Some of these values may be too high due to the probable increase in sensitivity of the photometer after use in very intense light.

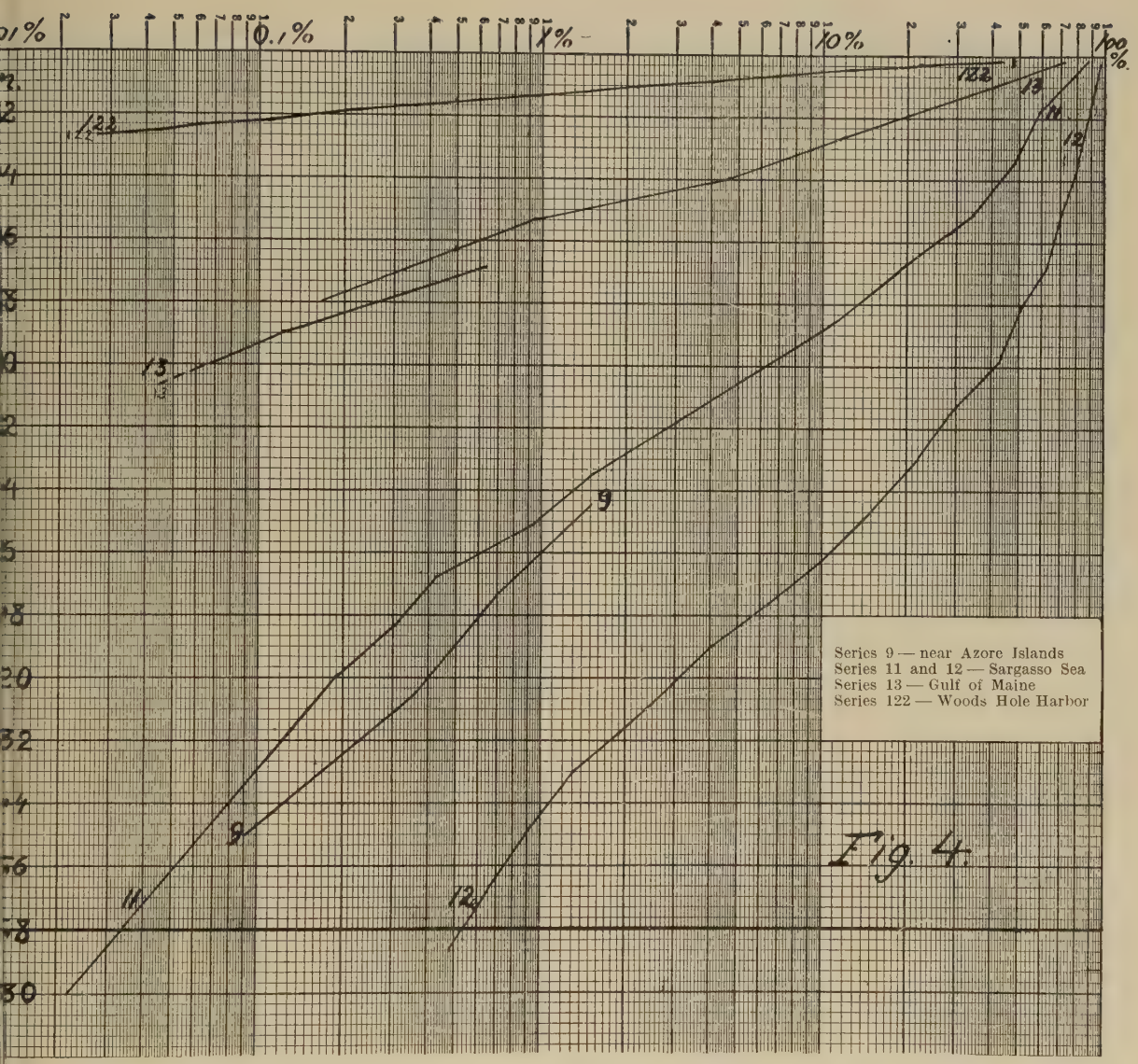

Fig. 4. Relation between depth and irradiation expressed as a percentage of the light just over the surface (logarithmic scale). Series 12 and Series 122 represent respectively the most transparent water and the least transparent water encountered.

The observations made approximately on longitude W. reveal an increasing transparency of the water, ticularly of the upper 20 meters, toward the south. ward the north, the transparency is slightly greater n that found in the Gulf of Maine (see Table II Fig. 3). The most transparent water encountered was in the Sargasso Sea where measurements were made down to 180 meters. This is the greatest depth to which light penetration has ever been measured by the photo-electric method. The transmissive exponent, k, as derived from the formula $\frac{I}{I_0} = e^{-kl}$ was found

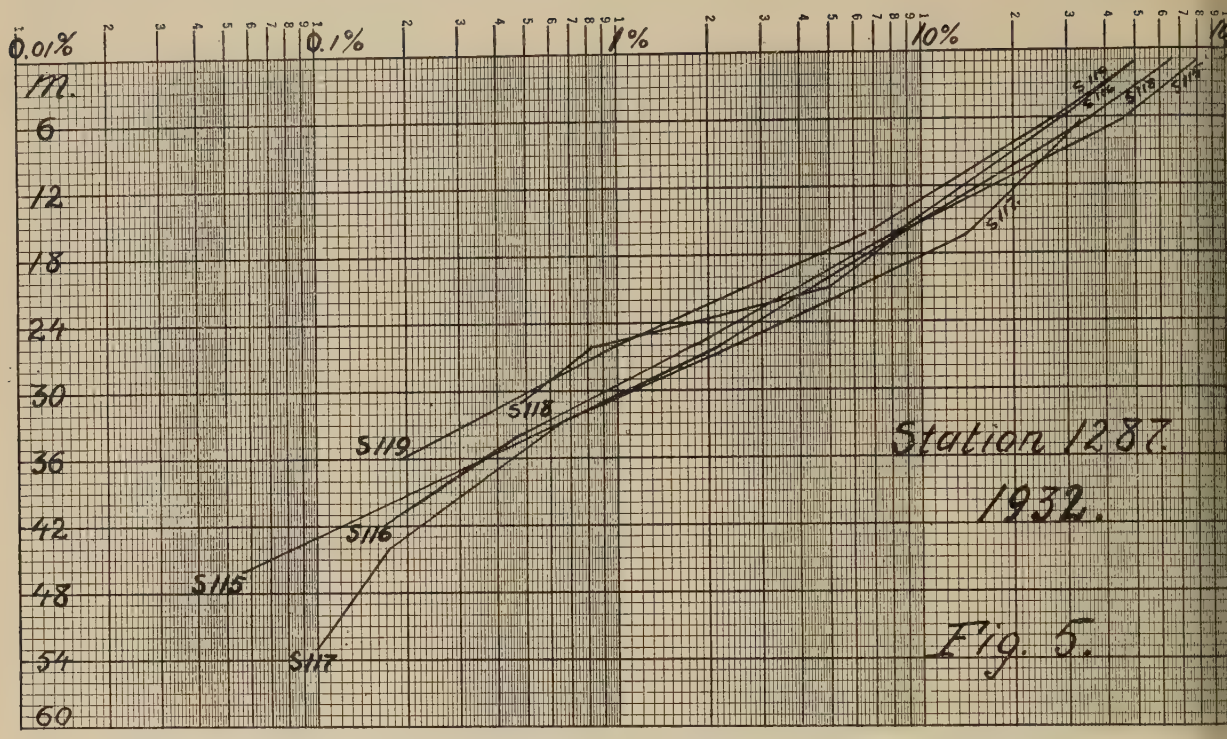

Fig. 5. Relation between depth and irradiation expressed in percentage of light just over the surface (logarithmic scale). The series shown (115 to 119 were all made at Station 1287 in the Gulf of Maine.

Table III. Summary of Gulf of Maine and Woods Hole Series.

Series	Station	Lat. N.	Long. W.	Date	Local sun time (24-hour scale)	Average altitude of sun	Average transmissive exponent o. depth studied	Irradiation at depth of 1 meter (percentage of surface light)	Range of irradiation on deck during series	Sea (Douglas Sea Scale)	Sky
				1931			k	%	Microwatts/cm.²		
13	1053	43°27′	67°39′	Aug. 24	1010—1120	49°	0.12	72	6,000— 8,000	Rough	Overcast
				1932							
112	1285	42°34′	69°37′	July 9	1302—1352	64°	0.15	92	16,000—17,000	Slight	Few cloud
113	1285	42°34′	69°37′	9	1907—1942	9°	0.12	63	200— 700	Moderate	— —
114	1286	42°30′	69°37′	10	0652—0732	16°	0.14	72	5,000— 7,000	—	— —
115	1287	43°04′	69°24′	10	1526—1632	41°	0.16	80	6,000—11,000	Slight	Overcast
116	—	—	—	11	0805—0847	29°	0.14	50	7,000—13,000	Rough	—
117	—	—	—	11	1203—1252	64°	0.14	—	15,000—16,000	Moderate	Clear
118	—	—	—	11	1837—1907	15°	0.16	66	600— 1,300	—	Few cloud
119	—	—	—	12	0612—0707	13°	0.16	50	4,000— 7,000	Slight	Clear
120	W.H. Harbor	41°31′	70°40′	Aug. 16	1149—1429	61°	0.43	40	12,000—15,000	Calm	Clear
121	—	—	—	22	1029—1134	41°	0.47	44	11,600—12,400	Calm (Glassy)	—
122	—	—	—	22	1339—1429	50°	0.49	44	11,800—12,400	Calm	—

have an average value of $k = 0.031$ for this series ich is lower than any previously reported using s method. The values in the surface strata are:

Meters	k
1—21	0.010
21—31	.013
31—41	.011
41—49	.028
49—59	.015

e least transparent water was encountered in Woods le harbor (see Table III and Fig. 4).

Examination was made of the extent to which the altitude of the sun, the condition of the sea surface, and the vertical distribution of the zoo-plankton affected the degree of penetration of light. Five series of observations under varying conditions at one station in the Gulf of Maine revealed no significant change in transparency (see Table III and Fig. 5).

The present measurements of submarine irradiation are found to be commensurate with those of previous investigators and, to a certain degree, extend our knowledge of the penetration of light into the sea.

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Diurnal Migration of Plankton in the Gulf of Maine and its Correlation with Changes in Submarine Irradiation.

By

George L. Clarke, Woods Hole.

Abstract.

Observations on the vertical distribution of copepods were made in the Gulf of Maine during a 12-hr. period, a 24-hr. period, and a 48-hr. period. Careful records of the light falling on deck were kept during these periods and measurements of the penetration of light into the sea were made at frequent intervals using the photo-electric method. These simultaneous observations, such as have never been made before, enabled quantitative information to be procured on the importance of light in controlling the diurnal migration of plankton.

Five closing nets were towed simultaneously at different depths from a single vertical cable. A method was devised for sending the nets down in the closed position, opening them simultaneously and towing them all together horizontally for 10 minutes, and then closing them again before hoisting to the surface. This method made it possible to sample accurately the upper 50 meters of water at intervals of less than one hour. Ordinarily ten series were made each day and in some cases the series was repeated in the 50 to 100 meter stratum.

The errors involved in the work at sea and in the sampling of the catch in the laboratory are at least as small as in other investigations of this type. Moreover, the methods used allow special dependance to be placed upon differences found among the hauls within each series.

The general vertical distribution of the three species studied was as follows: *Centropages typicus* inhabited the stratum of water above the thermocline (10 to 20 m.), *Calanus finmarchicus* was irregularly distributed, and *Metridia lucens* occurred below the thermocline (see Tables I, II and III and Fig. 3).

The adult females of *Metridia* exhibited the most marked diurnal migration, the level of maximum abundance rising in the afternoon and during the night and falling in the morning. These movements were found to coincide to a considerable extent with changes in submarine irradiation. In the case of the 48-hr. station the behavior of these animals on the second day is very closely the same as on the first day (see Table III and Fig. 5). The changes in the vertical distribution of the other groups of copepods were slight or quite irregular. In some cases, however, there was a definite tendency for the maximum to occur at greater depths at noon than at other times.

This investigation confirms the idea that light is the most important factor controlling diurnal migration. In addition the observations are shown to have a bearing on various of the theories regarding the manner in which light exerts its effect. For example the change of light intensity is shown probably not to be sufficiently rapid to reverse the sign of phototropism (as in Daphnia). Data on the rate of swimming of copepods indicate that these animals probably could keep pace with a given zone of light intensity as it changes its level during the course of the day

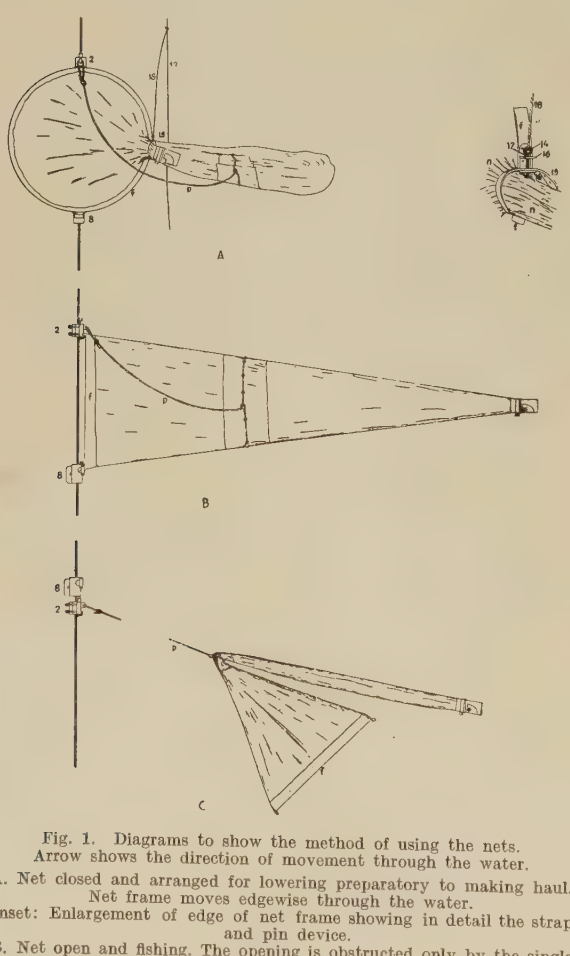

Fig. 1. Diagrams to show the method of using the nets. Arrow shows the direction of movement through the water.

A. Net closed and arranged for lowering preparatory to making haul. Net frame moves edgewise through the water.
Inset: Enlargement of edge of net frame showing in detail the strap and pin device.

B. Net open and fishing. The opening is obstructed only by the single cable passing across it.

C. Net closed and ready to be hoisted aboard. The net frame has been cast off and the net is drawn shut on the pursing rope. Note the 'messenger clamp' (8) which has dropped from the net above on to the trigger of the upper clamp (2) thus releasing the closing mechanism.

14. Pin
15. Strap
16. Brackets
17. Thread stopper
18. Cord attaching pin to (19)
19. Hand line to which all the pins are attached
f. frame
n. netting
p. pursing rope.

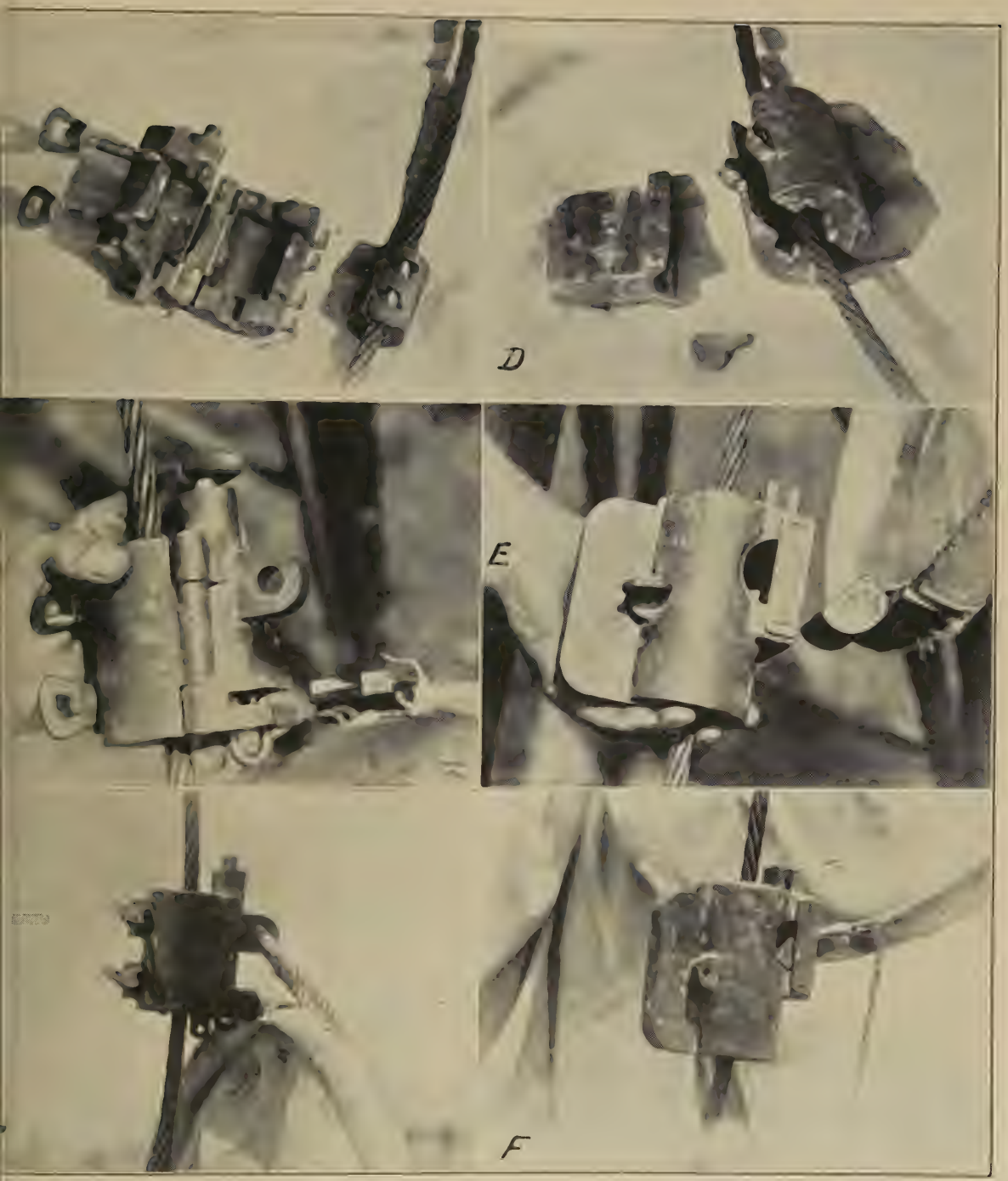

Fig. 2. Method of attaching closing net to cable.
For explanation see text.

A, *B*, and *C* — upper clamp and top of net frame.
D, *E*, and *F* — lower clamp and bottom of net frame.

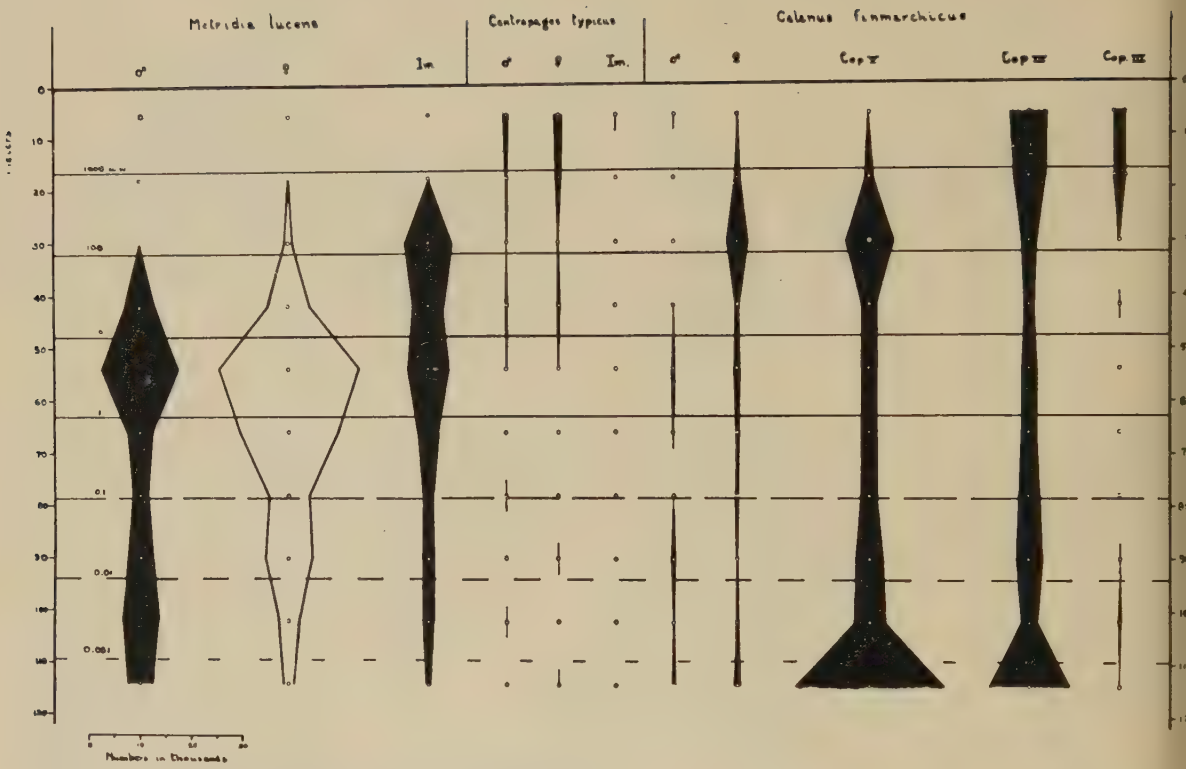

Fig. 3. General view of the vertical distribution and the relative numbers of the three species of copepods studied. The diagram for the adult females of Metridia is plotted on one-half the scale of the others. The depths at which light intensities of 1000 microwatts, 100 microwatts, etc., occurred are indicated by the horizontal lines. The upper five hauls (A244 to A248) were made at 1439 o'clock, the lower five (nos. A249 to A253) at 1515 o'clock on July 11, 1932 at Station 1287.

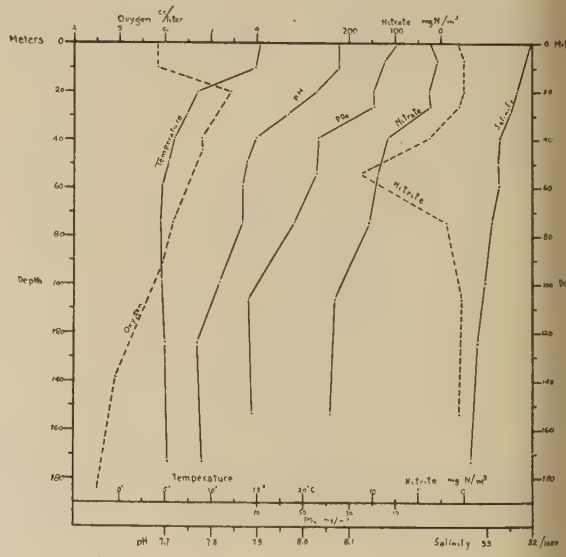

Fig. 4. Variation of Physical Factors with Depth.
Station 1287 (except oxygen which is for Station 1285).
The *pH* measurements were made by a spectro-photometric method using Cresol Red as an indicator. The *pK* value of Cresol Red was taken as 8.13 and corrected for salinity on the assumption of a salt error of —0.27. The solutions were measured at a temperature of 20°C. The values are not corrected for the change in temperature.

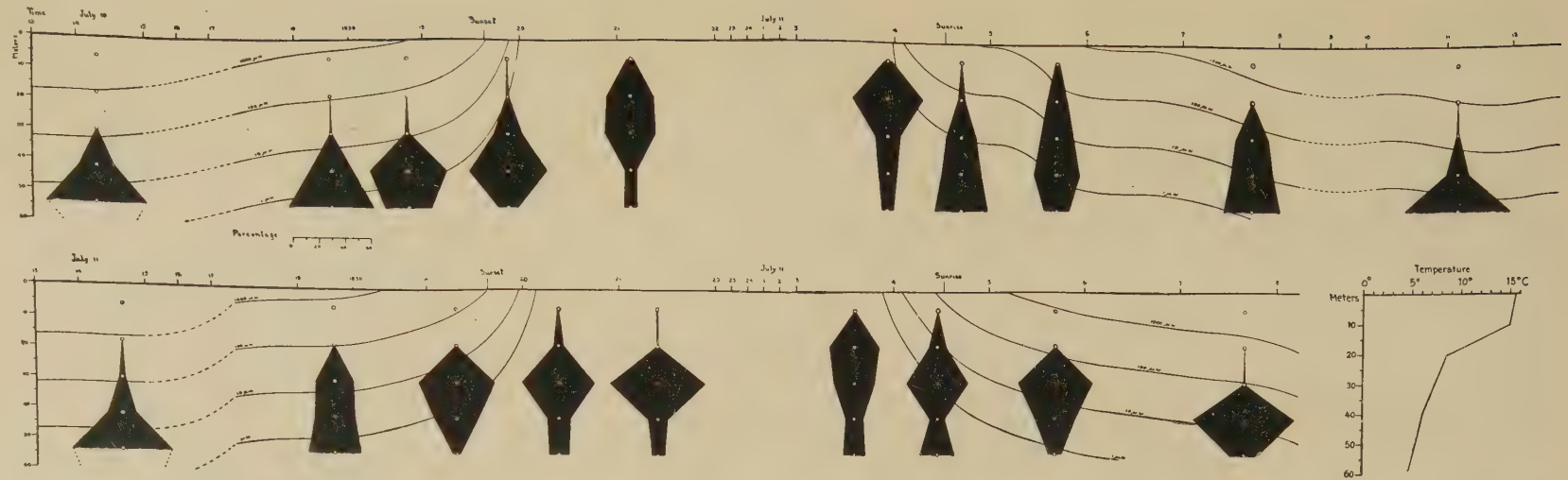

Fig. 5. The diurnal migration of the adult females of *Metridia lucens* during the 48-hour period of Station 1287 (July 10, 11, and 12, 1932). The position of the maximum early each afternoon is known to be 54 meters, and not lower, as shown by the deep series made immediately afterwards (see Table III). The changes in the light intensity are indicated by the lines representing the depth at which 1000 microwatts, 100 microwatts, etc., occurred. Where the lines are broken, a shortening of the time scale is indicated merely; observations were not discontinued during these periods.

Table I.

Station 1053, August 24, 1931, Lat. 43°27′ N., Long. 67°39′ W.
Sea Rough, Sky Overcast.
Sunrise at 0511.
Numbers of copepods in thousands. x = less than 500.

Haul no.	m.	Local Sun Time[1])	Irradiation at Surface Microwatts	Irradiation at Haul Depth Microwatts	Irradiation 30 min. before %	*Centropages typicus* Adult ♂	*Centropages typicus* Adult ♀	*Centropages typicus* Immature	*Calanus finmarchicus* Adult ♂	*Calanus finmarchicus* Adult ♀	*Calanus finmarchicus* Cop. V	*Calanus finmarchicus* Cop. IV	*Calanus finmarchicus* Cop. III
A55	4.5	0456	19	9.3		282	223	648	0	0	0	0	0
56	14	—	—	2.7		12	26	4	0	x	x	1	2
57	23	—	—	1.0		2	9	1	x	11	92	52	27
58	32	—	—	—	No light	x	2	1	x	15	88	34	3
59	46	—	—	—		1	2	1	x	6	15	2	0
60	4.5	0602	970	480	49	16	25	308	0	0	0	0	0
61	14	—	—	140	—	103	107	150	0	0	0	0	0
62	23	—	—	50	—	1	x	x	x	18	77	53	36
63	32	—	—	9.1	—	x	x	0	1	13	79	61	11
64	46	—	—	2.0	—	x	1	x	0	2	11	4	0
65	4.5	0656	1930	950	57	4	10	153	0	0	0	0	0
66	14	—	—	270	—	94	77	69	x	x	x	x	x
67	23	—	—	100	—	x	1	x	0	2	26	28	12
68	32	—	—	18	—	x	x	x	x	3	32	27	6
69	46	—	—	4.1	—	x	1	0	x	2	21	13	x
70	4.5	0807	5000	2450	64	9	11	296	0	0	0	0	0
71	14	—	—	700	—	1	1	35	0	0	0	0	0
72	23	—	—	260	—	26	21	84	0	0	0	0	0
73	32	—	—	47	—	2	4	1	0	x	x	x	x
74	46	—	—	10.5	—	x	x	x	x	x	x	1	x
75	4.5	1227	7100	3500	150	9	14	360	0	0	x	0	0
76	14	—	—	990	—	7	12	115	0	0	0	0	0
77	23	—	—	370	—	194	220	400	0	0	0	x	26
78	32	—	—	66	—	2	3	2	0	x	11	25	23
79	46	—	—	15	—	x	1	x	0	2	5	5	1
80	64	1330	7500	3.4	76	0	x	x	0	2	8	5	x
81	83	—	—	—	—	1*	2*	1*	x	1	3	1	x
82	101	—	—	—	—	x*	x*	x*	x	x	2	1	x
83	120	—	—	—	—	x*	x*	1*	0	x	2	1	0

* Mostly cast shells.
[1]) 24-hour scale. The time indicated is the middle of the 10-min. towing period.

Table II.

Hauls A145—A174, Station 1285, July 9, 1932, Lat. 42°34′ N., Long. 69°37′ W.
Sea Slight Sky clear Sunrise 0431 Sunset 1939
Hauls A175—A183, Station 1286, July 10, 1932, Lat. 42°30′ N., Long. 69°37′ W.
Sea Slight Sky few clouds Sunrise 0431 Sunset 1938
Numbers of copepods in hundreds x = less than 50

Haul no.	m.	Local Sun Time	IRRADIATION at Surface Microwatts	IRRADIATION at Haul Depth Microwatts	IRRADIATION 30 min. before %	*Centropages typicus* Adult ♂	*Centropages typicus* Adult ♀	*Centropages typicus* Imm.	*Calanus finmarchicus* Adult ♂	*Calanus finmarchicus* Adult ♀	*Calanus finmarchicus* Cop. V	*Calanus finmarchicus* Cop. IV	*Metridia lucens* Adult ♂	*Metridia lucens* Adult ♀	*Metridia lucens* Cop. V ♂	*Metridia lucens* Cop. V ♀	*Metridia lucens* Cop. IV ♂	*Metridia lucens* Cop. IV ♀	*Metridia lucens* Cop. III
A145	5	1119	14,900	6900	100	x	5	x	0	9	9	9	0	0	x	0	0	0	0
146	15	—	—	1500	—	0	0	0	0	2	13	6	0	0	2	2	0	0	0
147	25	—	—	330	—	0	0	0	x	7	15	5	0	0	x	x	0	0	0
148	35	—	—	46	—	0	0	0	0	2	20	14	x	x	3	10	x	x	0
149	45	—	—	13	—	0	0	0	0	4	29	19	x	x	1	4	x	1	x

aul o.	m.	Local Sun Time	IRRADIATION at Surface Microwatts	IRRADIATION at Haul Depth Microwatts	IRRADIATION 30 min. before %	*Centropages typicus* Adult ♂	*Centropages typicus* Adult ♀	*Centropages typicus* Im-mat.	*Calanus finmarchicus* Adult ♂	*Calanus finmarchicus* Adult ♀	*Calanus finmarchicus* Cop. V	*Calanus finmarchicus* Cop. IV	*Metridia lucens* Adult ♂	*Metridia lucens* Adult ♀	*Metridia lucens* Cop. V♂	*Metridia lucens* Cop. V♀	*Metridia lucens* Cop. IV♂	*Metridia lucens* Cop. IV♀	*Metridia lucens* Cop. III
50	55	1230	16,200	3.7	90	0	0	0	x	2	18	19	1	x	3	6	x	1	0
51	65	—	—	—	—	0	0	0	0	3	23	26	1	1	4	14	x	2	0
52	75	—	—	—	—	0	0	0	0	3	43	65	3	1	4	14	x	1	0
53	85	—	—	—	—	0	0	0	0	7	58	84	8	2	7	26	3	6	0
54	95	—	—	—	—	0	0	0	0	3	96	119	9	3	5	22	0	x	0
55	5	1812	2,700	950	180	4	15	1	0	2	2	3	0	0	x	0	0	0	0
56	15	—	—	240	—	1	5	x	0	4	4	2	0	0	x	x	0	0	0
57	25	—	—	110	—	x	3	0	0	2	10	6	x	x	2	6	0	0	0
58	35	—	—	12	—	x	1	0	0	x	1	3	x	x	1	4	0	x	0
59	45	—	—	2.7	—	x	x	0	0	x	5	8	x	x	2	5	x	x	0
60	55	1851	1,500	—	—	x	x	0	0	2	35	34	6	7	1	12	0	x	0
61	65	—	—	—	—	0	x	0	0	4	51	58	7	5	x	5	0	x	0
62	75	—	—	—	—	0	0	0	x	3	53	64	6	6	2	6	0	0	0
63	85	—	—	—	—	0	0	0	0	3	36	43	3	1	1	3	0	0	0
64	95	—	—	—	—	2	4	0	0	6	48	37	1	7	3	6	0	0	0
65	5	2123				3	17	1	0	2	5	3	0	2	x	3	0	0	0
66	15	—				x	2	x	0	1	2	x	0	1	x	4	0	0	0
67	25	—				x	0	0	0	3	26	14	1	16	1	8	0	0	0
68	35	—	No light	No light	No light	0	x	0	0	3	30	41	2	11	1	6	0	x	0
69	45	—				0	x	0	x	3	29	21	x	18	0	6	0	x	0
70	55	2214				0	0	0	0	5	53	62	5	75	5	13	0	x	0
71	65	—				0	0	0	0	6	42	44	4	72	2	7	0	0	0
72	75	—				0	0	0	0	3	40	54	7	58	3	15	0	x	0
73	85	—				0	x	0	0	5	53	58	3	76	3	14	x	1	0
74	95	—				0	0	0	1	4	40	49	4	76	2	16	x	x	0
75	5	0552	1,100	1200	42	0	18	1	0	2	3	3	0	x	0	x	0	0	0
76	15	—	—	330	—	x	x	0	x	6	11	7	x	x	4	8	0	0	0
77	25	—	—	100	—	x	0	0	0	3	21	29	3	1	3	8	x	x	0
78	35	—	—	21	—	x	x	0	0	2	12	25	2	2	2	7	0	x	0
79	45	—	—	4.4	—	x	x	0	0	2	19	43	2	3	1	5	0	x	0
80	55	0631	3,950	0.5	63	0	0	0	0	5	41	73	6	1	3	9	0	0	0
81	65	—	—	—	—	0	0	0	0	9	41	85	9	1	2	10	0	0	0
82	75	—	—	—	—	0	0	0	x	2	11	19	5	x	1	6	0	x	0
83	85	—	—	—	—	0	0	0	0	3	24	37	6	1	3	7	0	0	0

Table III.

Station 1287, Lat. 43°04′ N., Long. 69°24′ W.

			Sea	Sky	Sunrise	Sunset
lls	A184—A218	July 10, 1932	Smooth	Clear	0431	1938
lls	A219—A273	July 11, 1932	Moderate	Overcast, becoming clear	0432	1938
lls	A274—A293	July 12, 1932	Slight	Clear	0433	1939

Number of Copepods in thousands x = less than 500

l	Depth Meters	Local Sun Time	Irradiation at Surface Microwatts	Irradiation at Haul Depth Microwatts	Irradiation 30 min. before %	*Centropages typicus* Adult ♂	*Centropages typicus* Adult ♀	*Centropages typicus* Im-mat.	*Calanus finmarchicus* Adult ♂	*Calanus finmarchicus* Adult ♀	*Calanus finmarchicus* Cop. V	*Calanus finmarchicus* Cop. IV	*Calanus finmarchicus* Cop. III	*Metridia lucens* Adult ♂	*Metridia lucens* Adult ♀	*Metridia lucens* Im-mat.
4	6	1418	15,800	7,400	102	4	11	1	x	1	1	4	1	0	0	0
5	18	—	—	1,100	—	3	4	0	0	1	1	4	4	0	0	0
6	30	—	—	170	—	0	x	x	0	2	4	2	x	0	0	x
7	42	—	—	19	—	0	0	0	x	1	3	2	0	9	50	12
8	54	—	—	—	—	0	0	0	x	1	5	1	0	13	141	25
9	66	1505	13,400	—	108	0	0	0	0	1	4	1	0	3	64	3
0	78	—	—	—	—	x	x	0	0	x	4	2	0	3	10	3
	(Lost)															
2	102	—	—	—	—	0	0	0	0	0	6	5	x	0	1	2
3	114	—	—	—	—	x	x	x	0	0	11	5	0	x	2	1

Table III (continued)

Haul no.	Depth Meters	Local Sun Time	Irradiation at Surface Microwatts	Irradiation at Haul Depth Microwatts	Irradiation 30 min. before %	*Centropages typicus*			*Calanus finmarchicus*					*Metridia lucens*		
						Adult ♂	Adult ♀	Immat.	Adult ♂	Adult ♀	Cop. V	Cop. IV	Cop. III	Adult ♂	Adult ♀	Immat.
199	6	1821	2,050	960	147	4	7	x	0	1	1	2	2	0	0	x
200	18	—	—	140	—	x	0	0	0	2	9	5	3	0	0	2
201	30	—	—	22	—	0	0	0	0	x	4	1	x	0	1	1
202	42	—	—	2.5	—	x	0	0	x	1	2	2	x	8	45	21
203	54	—	—	—	—	0	0	0	x	1	2	1	0	24	89	18
204	6	1854	1,190	560	173	2	6	0	0	x	1	3	1	0	x	0
205	18	—	—	80	—	0	0	0	0	2	6	5	2	0	0	1
206	30	—	—	13	—	0	0	0	0	1	9	3	0	0	4	2
207	42	—	—	1.4	—	0	0	0	0	0	3	2	0	10	78	22
208	54	—	—	—	—	0	0	0	0	1	1	11	x	6	48	13
209	6	1952	16	8	267	5	7	2	0	1	1	11	5	0	x	1
210	18	—	—	1.1	—	0	x	x	x	3	2	1	1	0	3	1
211	30	—	—	—	—	0	0	0	0	1	12	2	x	0	34	3
212	42	—	—	—	—	0	0	0	0	1	8	3	0	3	91	12
213	54	—	—	—	—	2	2	0	0	1	2	1	0	13	23	14
214	6	2107	0	0	No light	4	7	1	0	1	1	6	3	0	6	2
215	18	—	—	0		0	0	0	0	7	11	12	4	x	46	7
216	30	—	—	0		0	0	0	0	5	21	5	0	0	48	5
217	42	—	—	0		0	0	0	x	1	2	1	0	7	12	6
218	54	—	—	0		0	x	0	x	x	4	3	0	12	12	9
219	6	0356	0	0	No light	6	5	1	x	2	1	4	1	0	3	1
220	18	—	—	0		0	x	0	0	1	5	3	0	x	25	6
221	30	—	—	0		0	0	0	0	0	2	1	0	x	9	3
222	42	—	—	0		0	0	0	0	1	2	1	0	1	6	4
223	54	—	—	0		x	0	0	x	1	1	1	0	1	4	3
224	6	0441	114	33	No light	3	3	2	0	1	1	5	1	0	0	1
225	18	—	—	7.1		x	1	0	x	2	3	3	x	x	7	1
226	30	—	—	1.0		0	0	0	0	2	15	3	0	0	32	10
227	42	—	—	—		0	0	0	0	3	8	2	0	2	42	14
228	54	—	—	—		0	0	0	x	2	10	2	x	6	57	14
229	6	0540	800	230	24	0	2	1	x	1	1	4	1	x	1	1
230	18	—	—	50	—	0	x	0	x	2	1	2	1	0	7	1
231	30	—	—	7.4	—	0	0	0	0	1	5	3	0	0	12	3
232	42	—	—	1.4	—	0	0	0	0	1	4	1	0	1	17	7
233	54	—	—	—	—	0	x	x	x	1	2	1	0	3	9	5
234	6	0742	5,360	1,600	49	2	2	x	x	x	1	4	2	0	0	0
235	18	—	—	330	—	0	x	0	x	4	6	5	1	0	1	2
236	30	—	—	49	—	0	0	0	0	5	12	5	0	x	39	7
237	42	—	—	9.1	—	x	0	0	0	3	5	2	0	2	51	7
238	54	—	—	—	—	0	0	0	0	2	5	2	0	2	68	10
239	6	1109	17,100	6,000	Variable	1	1	0	0	0	x	3	2	0	x	x
240	18	—	—	1,800		1	1	0	x	1	1	2	x	0	x	x
241	30	—	—	190		x	0	0	x	7	33	9	0	0	1	5
242	42	—	—	38		0	x	0	x	3	7	3	x	8	8	12
243	54	—	—	16		0	0	0	x	2	5	3	0	6	40	6
244	6	1439	13,900	4,900	95	1	1	x	x	x	1	7	2	0	0	0
245	18	—	—	1,500	—	x	1	0	0	1	2	6	2	0	x	x
246	30	—	—	150	—	0	0	0	0	4	9	3	0	0	3	9
247	42	—	—	31	—	x	x	0	0	1	3	2	x	6	15	6
248	54	—	—	13	—	0	0	0	x	1	3	3	0	15	55	8

Table III (continued)

aul no.	Depth Meters	Local Sun Time	Irradiation at Surface Microwatts	Irradiation at Haul Depth Microwatts	Irradiation 30 min. before %	*Centropages typicus*			*Calanus finmarchicus*					*Metridia lucens*		
						Adult ♂	Adult ♀	Immat.	Adult ♂	Adult ♀	Cop. V	Cop. IV	Cop. III	Adult ♂	Adult ♀	Immat.
49	66	1515	12,500	0.56	109	0	0	0	x	x	3	3	0	5	37	4
50	78	—	—	—	—	x	0	0	0	x	3	4	0	3	15	2
51	90	—	—	—	—	0	x	0	x	x	5	5	x	5	19	2
52	102	—	—	—	—	x	0	0	0	x	6	3	x	7	7	2
53	114	—	—	—	—	0	x	0	x	1	28	16	0	5	3	1
54	6	1821	1,820	660	180	3	4	x	0	x	1	5	1	0	0	0
55	18	—	—	130	—	0	1	0	x	3	9	6	1	x	0	1
56	30	—	—	9.8	—	0	0	0	0	7	18	2	0	0	98	12
57	42	—	—	2.9	—	0	0	0	x	2	9	2	0	x	106	18
58	54	—	—	—	—	0	0	0	x	x	7	x	0	7	134	16
59	6	1919	340	120	300	3	6	1	x	1	1	5	2	0	0	0
60	18	—	—	24	—	x	2	0	0	2	2	3	1	0	1	x
61	30	—	—	1.8	—	0	0	0	0	x	12	0	0	0	153	9
62	42	—	—	—	—	0	0	0	0	0	7	2	0	2	88	14
63	54	—	—	—	—	x	x	0	0	x	3	2	0	7	16	6
64	6	2022	0	0	28 μ W. at surface	5	11	1	0	1	1	5	1	0	1	0
65	18	—	—	0		1	4	0	x	1	1	2	1	0	9	1
66	30	—	—	0		0	0	0	0	x	5	x	0	0	62	2
67	42	—	—	0		x	0	0	x	3	6	3	0	1	19	4
68	54	—	—	0		0	x	0	0	x	5	2	x	7	17	6
69	6	2126	0	0	No light	5	6	0	0	x	1	8	3	0	2	x
70	18	—	—	0		1	3	x	x	1	x	2	1	0	2	x
71	30	—	—	0		0	0	0	0	3	9	x	x	x	141	21
72	42	—	—	0		0	0	0	1	1	3	2	0	2	28	9
73	54	—	—	0		x	0	0	0	x	6	4	0	6	18	9
74	6	0337	0	0	No light	2	7	x	0	x	1	7	2	0	x	0
75	18	—	—	0		x	x	0	0	1	1	3	x	0	60	3
76	30	—	—	0		0	0	0	0	2	8	2	0	2	52	3
77	42	—	—	0		0	0	0	0	1	7	3	0	4	21	5
78	54	—	—	0		0	x	0	0	3	7	3	0	7	27	6
79	6	0428	124	33	2	2	6	1	0	1	1	10	2	0	0	0
80	18	—	—	5.8	—	0	1	0	0	1	3	2	1	0	11	2
81	30	—	—	0.6	—	0	0	0	0	x	4	1	0	1	38	13
82	42	—	—	—	—	x	x	0	x	2	4	1	0	11	10	4
83	54	—	—	—	—	0	x	0	0	2	5	3	x	8	22	9
84	6	0542	2,360	640	47	3	5	1	0	1	1	10	1	0	0	x
85	18	—	—	110	—	x	1	0	0	1	2	1	x	0	x	1
86	30	—	—	12	—	2	2	x	0	1	6	8	2	0	36	11
87	42	—	—	3.8	—	0	0	x	0	x	2	1	0	13	19	15
88	54	—	—	—	—	0	0	x	x	x	1	1	x	11	6	3
89	6	0739	8,930	2,400	86	1	3	1	x	1	1	6	1	0	x	0
90	18	—	—	420	—	x	x	x	0	1	1	1	1	0	0	1
91	30	—	—	46	—	0	0	0	0	1	6	1	0	0	1	1
92	42	—	—	14	—	0	0	0	x	x	2	2	0	0	105	32
93	54	—	—	2.4	—	0	0	0	x	0	2	2	0	3	29	7

Migrations verticales périodiques des Animaux benthiques littoraux.

Par

Louis Fage, Paris.

Le Zooplancton littoral, dont il sera seul question ici, comprend non seulement les organismes qui, comme la plupart des Copépodes, les Appendiculaires etc., mènent, leur vie durant, une existence pélagique, mais il se compose aussi d'organismes qui, normalement benthiques, ont, au cours de leur cycle vital, une ou plusieurs phases pélagiques pendant lesquelles ils se répandent en masse à la surface de la mer. Pour certains, cette phase est limitée à la durée du développement des stades larvaires; pour d'autres, ce sont les adultes qui, à un moment donné, se libèrent du fond et nagent entre deux eaux. Ces derniers, que l'on pourrait appeler les pélagiques temporaires, méritent à plus d'un titre de retenir notre attention, d'abord parce qu'ils sont moins connus, peut-être, que les précédents et ensuite parce qu'il n'est pas sans intérêt de voir si leurs déplacements sont soumis au même déterminisme que ceux des pélagiques permanents.

C'est dans l'intention d'étudier cette question qu'à Banyuls-sur-mer, avec le Prof. Racovitza et à Concarneau, avec le Dr. R. Legendre j'ai entrepris, pendant plusieurs années, une série de pêches pélagiques dont les résultats ont fait l'objet de publications spéciales sur les Annélides, les Pycnogonides et les Crustacés ainsi récoltés[1]); je me bornerai ici à en développer les conclusions.

Pour ces pêches, qui se faisaient de nuit, nous avons utilisé une source lumineuse, immergée ou non, afin de grouper et de retenir auprès de nous les organismes épars dans le plancton, que nous capturions avec un simple haveneau. Pratiquées d'abord d'une façon sporadique et en des points variés du littoral, ces pêches sont par la suite, à Concarneau, devenues régulières, et ont été effectuées dans les premières heures de la nuit, au même endroit, durant plus d'une année, à raison d'une par semaine, aux syzygies et à chaque quartier. Le point choisi se trouve dans une zone abritée, peu éloignée du rivage, mais en deçà de la limite des marées, sur un fond de 3 à 4 mètres, où le sable apparaît entre les Zostères et les Laminaires. Avant ou après les opérations, une pêche de surface au filet fin était, en outre, fréquemment exécutée, dans une zone non éclairée.

Sans doute, en limitant ainsi notre équipement et en nous plaçant dans des conditions de temps et de lieu strictement déterminées, nous limitions du même coup la variété des captures, mais nous avions aussi l'énorme avantage d'obtenir des pêches dont les résultats sont strictement comparables d'un bout de l'année à l'autre. Et c'est grâce à cela qu'il nous est maintenant possible d'émettre, sur la phase pélagique des espèces récoltées, son importance, sa durée, des conclusions qui, autrement, nous eussent été interdites.

D'ailleurs, ce procédé fort simple nous a cependant procuré 68 espèces d'Annélides polychètes, 2 espèces de Pycnogonides, 3 espèces d'Ostracodes, 11 espèces de Mysidacés, 17 espèces de Cumacés, 11 espèces d'Isopodes, plus de 50 espèces d'Amphipodes, dont certaines représentées par des milliers d'individus. Il faut donc admettre que, tout auprès de la côte, la surface de la mer est envahie, la nuit, par une foule grouillante d'organismes qu'on n'y rencontre point le jour.

En effet, la grande majorité de ces espèces sont franchement benthiques et se prennent de jour sur le fond. Parmi les Annélides: les Phyllodociens, les Hésioniens, les Néréidiens, les Nephthydiens, les Euniciens, le *Polyophthalmus pictus*, les *Prionospio*, le *Scalibregma inflatum* sont couramment capturés par la drague ou, à marée basse, sous les pierres, dans les trous de rocher. C'est dans les mêmes conditions et parmi les Algues qu'on rencontre habituellement ce Pycnogonide, le *Nymphon gracile*, qui s'est montré si fréquent dans nos pêches pélagiques. Parmi les Ostracodes, l'*Asterope mariae*, le *Philomedes interpuncta* dont nous trouvons, la nuit, par milliers les mâles adultes dans notre filet, se tiennent pendant le jour dans le sable vaseux où les femelles se creusent même une sorte de loge. Tous les Cumacés sont fouisseurs et vivent également dans le sable et la vase. La plupart de nos Amphipodes se prennent à la drague pendant le jour, les plus nombreux ou les plus constants dans les pêches nocturnes de surface, le *Urothoë*, le *Metaphoxus Fultoni*, le *Perioculodes longimanus*, le *Nototropis Schwammerdami*, le *Guernea coalita* sont des formes sédentaires; le *Tritaeta gibbosa*

[1]) Pêches planctoniques à la lumière, effectuées à Banyuls-sur-mer et à Concarneau (Arch. de Zool. Exp. et Gén. T. 67, fasc. 2; T. 74, fasc. 14; T. 76, fasc. 3).

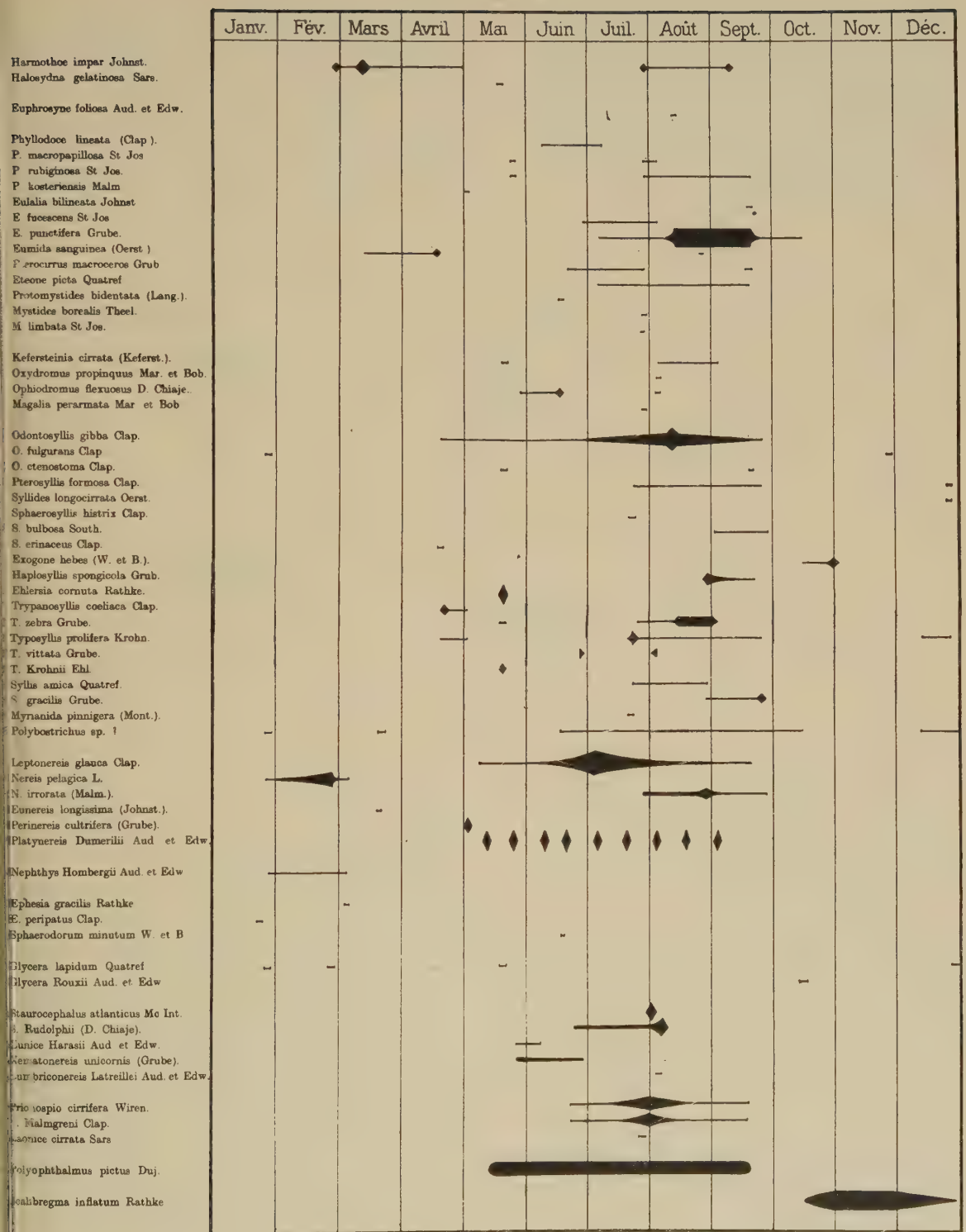

Fig. 1. Abondance relative et fréquence des Annélides polychètes dans le plancton nocturne de Concarneau.

se façonne même une demeure dans les Eponges; d'autres, comme le *Dexamine spinosa*, se tiennent parmi les Algues en compagnie de certains Isopodes (*Idotea*). Les Mysidacés, toujours en mouvement, restent au voisinage du fond jusqu'au crépuscule et se comportent à la côte comme, au large, certains Euphausiacés (*Nyctiphanes*, *Meganyctiphanes*, *Thysanoessa*) dont Hickling (1925), par des pêches exécutées d'heure en heure, dans la région des Smalls, a suivi la migration verticale.

rythme ou dans son amplitude. En tout cas, lorsque la lumière revient, le plancton émigre en profondeur pour reprendre peu à peu la position de départ. Sensibilisés à l'action de la lumière par un séjour prolongé à l'obscurité, leur descente sera beaucoup plus rapide que leur ascension. "Elle pourra même commencer avant le retour de la lumière dans les nuits très obscures, car j'ai souvent constaté, dit-il, qu'un séjour très prolongé à l'obscurité totale amène un tassement des animaux sur le fond des vases d'expérience. Je

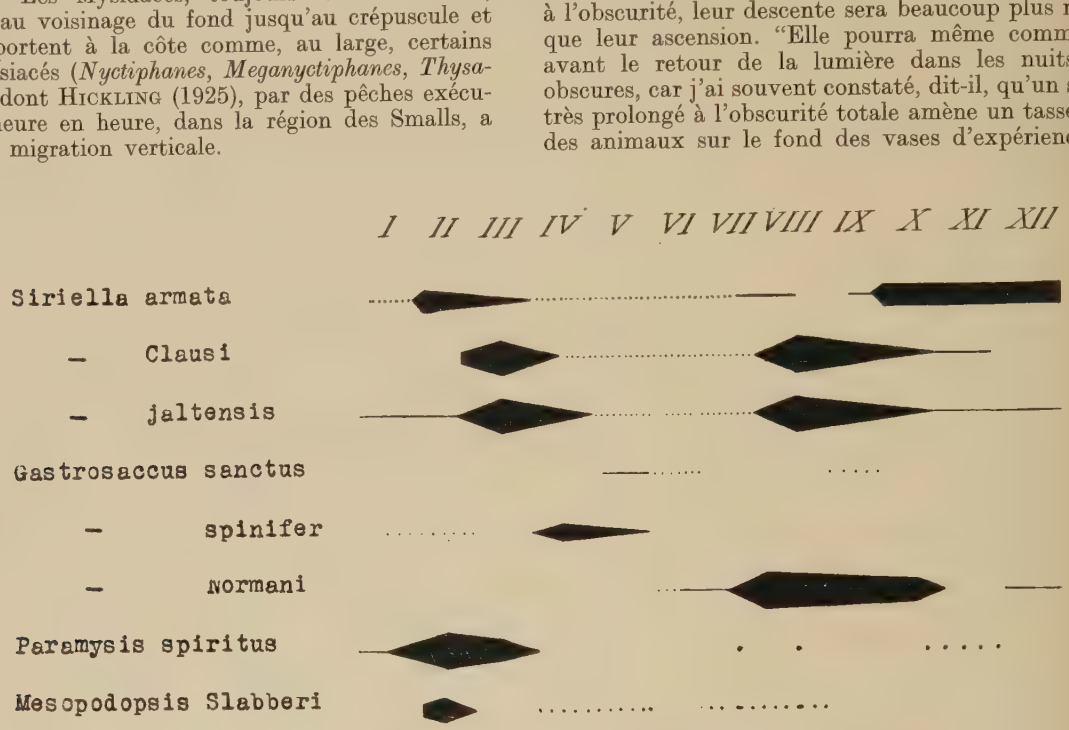

Fig. 2. Abondance relative et fréquence des Mysidacés dans le plancton nocturne de Concarneau.

Aussi bien, la réalité d'une ascension périodique de tous ces organismes n'est plus discutée. Une bonne revue de la question a été publiée en 1927 par F. S. Russell, et ses travaux ultérieurs de même que ceux exposés ici, montrent l'importance que donne à ce phénomène son caractère de grande généralité.

* * *

On admet que pour les organismes pélagiques permanents, qui exécutent des migrations verticales suivant ce même rythme nycthéméral, le facteur dont l'influence se fait sentir d'une façon prépondérante sur ces déplacements est le facteur éclairement. Je rappellerai que M. Rose (1925) étudiant spécialement ce problème en donne l'explication suivante. Les animaux phototropiques sont échelonnés pendant le jour de la surface à une certaine profondeur selon la position de leur zone optimum propre à chacun d'eux. A mesure que le soleil décroît sur l'horizon, cette zone optimum remonte vers la surface entrainant dans le même sens les animaux qui s'y trouvent assujettis. Si, dans leur migration verticale, ceux-ci rencontrent des eaux de qualité différente — plus chaudes, plus diluées, plus aérées — par le jeu des sensibilités différencielles, leur montée est modifiée dans son

crois qu'il est dû à une diminution des mouvements natatoires par disparition de l'effet photocinétique de l'excitant lumineux. Pour les formes non phototropiques, la montée et la descente seraient produites par les variations de cette photocinèse et le jeu de leurs sensibilités différentielles".

Cette théorie explicative, généralement adoptée paraît en effet susceptible de rendre compte d'une manière satisfaisante de l'ensemble des migrations verticales journalières des animaux pélagiques permanents. L'auteur semble même vouloir l'appliquer au cas des formes benthiques lorsqu'il écrit: "toujours dans les mers peu profondes, le plancton de nuit est très chargé de formes benthoniques (Amphipodes, Ostracodes, Cumacés, Harpacticidés, etc.) attirées en surface par le même mécanisme". En réalité, le phénomène est ici beaucoup plus complexe du fait que ces formes benthiques, qui sont précisément celles dont nous nous occupons, sont liées au fond sur lequel elles passent la plus grande partie de leur existence. On l'on sait depuis longtemps — les expériences déjà anciennes de J. Loeb l'ont montré d'une façon nette et j'ai donné moi-même à ce sujet des précisions concernant les Cumacés et certains Amphipodes recueillis dans le plancton — que les excitations de contact

uvent dominer et même inhiber complètement toute action à la lumière. C'est pourquoi l'on doit s'attendre à trouver dans leur comportement une grande versité d'allure qui tient en partie au jeu combiné l'un et l'autre de ces deux facteurs.

Ceci dit il n'est pas douteux que les variations rnalières de l'intensité lumineuse, variations facilent perceptibles jusque sur le fond dans la zone orale, jouent un rôle de premier plan dans les placements des organismes que nous avons observés.

nettement plus développés que ceux des femelles, et tel est de beaucoup le cas le plus général, ce sont eux qui prédominent dans nos pêches. S'il arrive que, pour une espèce donnée, les femelles paraissent habituellement aussi sensibles que les mâles à l'action de la lumière et, comme eux, accomplissent une migration nocturne ascensionnelle on remarque alors que les deux sexes sont dans ce cas bien pourvus d'organes visuels. De récentes recherches de Volsky et J.-S. Huxley (1932) ont d'ailleurs montré que les mutants

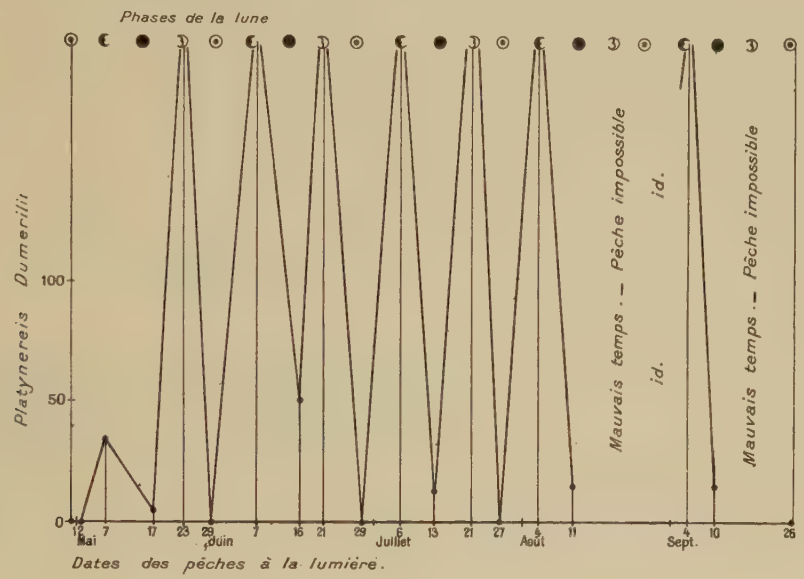

Fig. 3. Rythme lunaire des essaimages du *Platynereis Dumerillii* à Concarneau.

s les animaux que nous avons récoltés la nuit à urface, dans le temps où leur rythme nycthéméral roduit avec régularité, se sont montrés photoibles. C'est même grâce à cette sensibilité qu'ils roupaient en aussi grand nombre autour du foyer neux qui servait à nos pêches, et dont la faible nsité les attirait. Nous avons, de plus, noté que, les Crustacés, les espèces dont les yeux sont iculièrement bien développés sont parmi les membres plus fidèles du plancton nocturne.

uo de plus instructif à cet égard que le cas offert es Ostracodes? Ceux-ci sont ou bien aveugles ou pourvus d'ocelles extrêmement réduits. Seuls les *idinidae* ont une paire d'yeux composés, seuls ils sont représentés dans nos pêches. Bien plus, âles sont à ce point de vue incomparablement x dotés que les femelles, et ce sont eux, précisé, qui, durant presque toute l'année, sont soumis rythme nycthéméral régulier que les femelles loin de subir avec cette constance. Les mêmes ularités s'observent chez les Cumacés et les hipodes: toutes les fois où les mâles ont les yeux

albinos ou décolorés du *Gammarus Chevreuxi*, qui n'ont ni rétinules, ni nerfs optiques, n'accusent aucun phototactisme à l'encontre des individus normaux ou à yeux rouges qui sont nettement négatifs. On peut rappeler, à ce propos, que chez les Annélides polychètes un des caractères des formes épitoques — qui naturellement sont en majorité dans nos captures — est un énorme acroissement des yeux. La relation — particulièrement frappante chez nos Crustacés — entre le degré de développement des organes visuels et la régularité des migrations verticales est donc bien d'accord avec l'opinion qui fait de celles-ci une réponse à des excitations lumineuses.

* * *

Mais, à vrai dire, cette réponse est inconstante. Il est en effet tout à fait exceptionnel que le rythme se répète quotidiennement chez la même espèce d'un bout de l'année à l'autre. Parmi les formes dont on peut ainsi rencontrer des représentants la nuit en surface à toutes les époques de l'année, si, pour les unes, le *Siriella jaltensis* ou le *Dexamine spinosa* par

exemple, les deux sexes et les jeunes sont présents; pour les autres, nos Ostracodes, le *Nannastacus unguiculatus*, le *Cumella pygmaea*, le *Tritaeta gibbosa*, le *Metaphoxus Fultoni*, le *Perioculodes longimanus*, les *Euridice*, les mâles seuls y sont ainsi représentés avec cette régularité. Pour tous enfin, le nombre des individus est extrêmement variable: il existe des périodes d'abondance, des poussées, précédées et suivies de périodes où le nombre des individus, à chaque pêche, se chiffre par unité. Donc, même pour ces espèces privilégiées, leur rythme est sujet à des variations

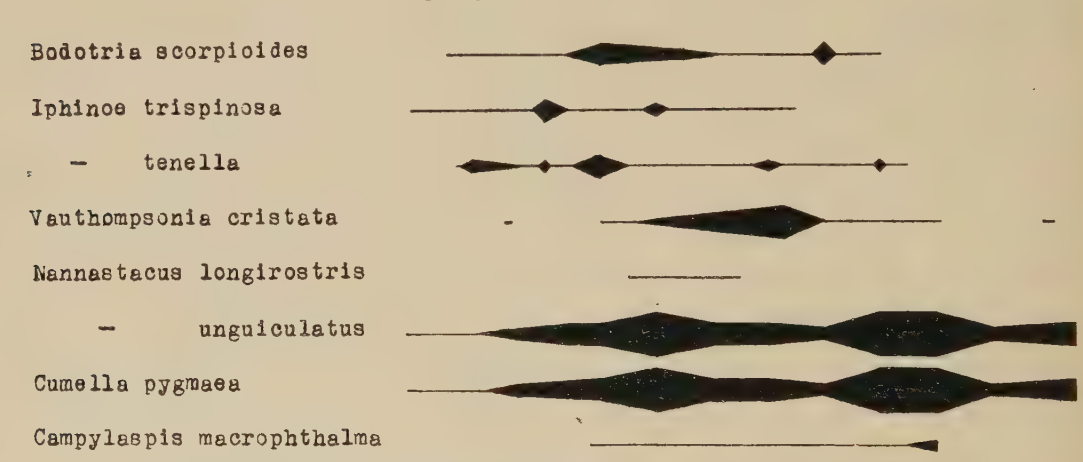

Fig. 4. Abondance relative et fréquence des Cumacés dans le plancton nocturne de Concarneau.

extrêmement importantes quant au nombre et à la catégorie des individus qui s'y trouvent soumis.

Mais ces variations sont encore bien plus grandes pour les autres espèces. Pour elles, en effet, leur présence, la nuit, en surface, est strictement limitée à une période plus ou moins courte. Citons, à titre d'exemple le *Gastrosaccus Normani* qui, à Concarneau, n'exécute sa montée en surface d'une façon régulière qu'à partir de la fin de l'été et durant l'automne, et qui apparaît en Mai quand le *G. spinifer* a déjà disparu pour disparaître à son tour à la fin de Décembre quand celui-ci apparaît en Janvier; le *Paramysis spiritus* dont la migration verticale ne se produit qu'à la saison froide, comme celle des *Nototropis* et celle de l'*Urothoë Grimaldi* qui est limitée aux mois de décembre, janvier et février; le *Vauthompsonia cristata* qui est au contraire, absent de la surface en hiver et dont l'ascension des femelles est strictement limitée au mois de septembre. Bien d'autres cas de ce genre ont été signalés au cours de nos recherches et témoignent d'une localisation dans le temps du rythme nycthéméral de la plupart des espèces considérées, et de sa subordination à un rythme saisonnier. Je rappellerai seulement ce que nous ont enseigné à ce sujet les Polychètes dont, à Concarneau, les grands essaimages en surface ont lieu, pour la majorité des espèces, pendant la saison chaude, tandis que, cependant, le *Scalibregma inflatum*, le *Glycera lapidum*, le *Nereis pelagica*, le *Nephthys Hombergii* n'essaiment qu'en hiver.

Il y a plus, même pendant la saison d'essaimage, ou d'abondance qui peut être assez longue, on note des variations à très courtes périodes, parfois extrêmement importantes. C'est ainsi qu'à Concarneau le *Nereis pelagica* n'essaime en surface qu'au dernier quartier de la lune de janvier et février; le *Leptonereis glauca*, au dernier quartier et à la nouvelle lune de juin à août; le *Nereis irrorata*, au dernier quartier et à la nouvelle lune d'août à septembre; le *Platynereis Dumerillii*[1]), au premier et au dernier quartier de juillet à septembre; l'*Eulalia punctifera*, au dernier quartier d'août et septembre; le *Glycera lapidum*, au dernier quartier de décembre, janvier et février; les *Staurocephalus*, au premier quartier de juin, juillet août; les *Prionospio* au premier et au dernier quartier de juillet et août; le *Polyophthalmus pictus*, entre la nouvelle lune et le premier quartier de mai à septembre. Pour toutes ces espèces, dans l'intervalle de ces périodes strictement limitées, durant lesquelles les captures, toujours extrêmement abondantes, se chiffrent parfois par milliers, on ne rencontre que quelques individus errant dans le plancton. Des variations de même amplitude pourraient être citées chez les Amphipodes, chez les Cumacés.

Nous sommes donc conduits à admettre que la sensibilité à la lumière de tous ces animaux déjà variable suivant les espèces et suivant les sexes, subit aussi chez une même espèce des modifications saisonnières, voire journalières.

* * *

[1]) Voir figure 3.

Parmi les facteurs du milieu extérieur qu'on ourrait invoquer comme responsables des variations aisonnières, celui qui semble tout d'abord devoir être etenu est la température. En effet, dans les conitions où nous nous sommes placés, à Concarneau, s variations de salinité sont extrêmement faibles, et, our la même raison, il n'y a pas lieu de s'arrêter ux variations de la teneur en oxygène. L'agitation e la mer, les courants de marées peuvent sans aucun oute géner dans leurs déplacements les organismes agiles, nageurs peu puissants, que sont les Crustacés nt il est ici question. Mais il ne saurait s'agir que 'une entrave momentanée, pouvant expliquer des

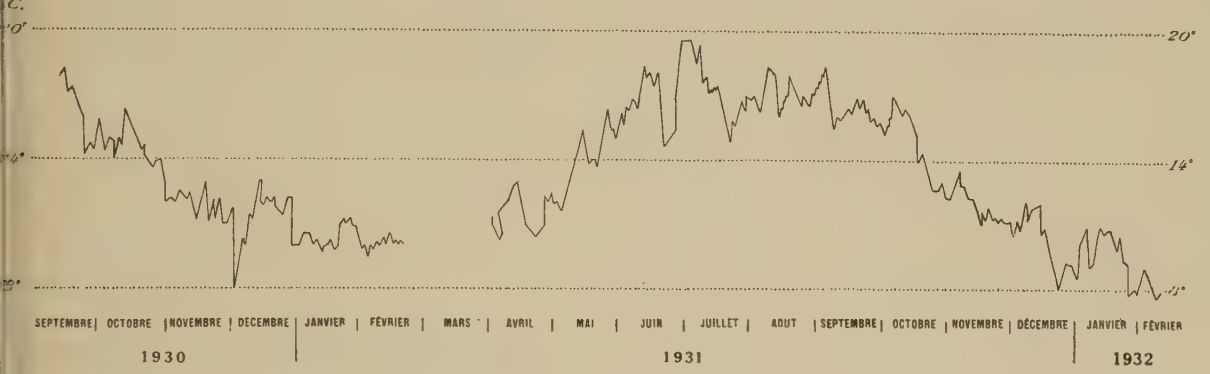

Fig. 5. Températures de surface à Concarneau.

riations quantitatives journalières, mais non la ésence ou l'absence de telle espèce pendant une ngue suite de jours. Quant au *pH* dont on sait que valeur augmente de décembre à janvier, atteint n maximum en mai, puis s'abaisse légèrement en in et juillet, pour remonter en août et redescendre suite, ses variations sont d'ordre biologique (photonthèse, respiration) en rapport avec la durée d'ination. Rose estime, d'ailleurs, qu'elles sont, dans conditions normales, insuffisantes pour modifier nsiblement le phototropisme et la distribution vertie du plancton. Cependant la durée d'insolation ou, s exactement, de la longueur du jour est un facteur i chez des espèces photosensibles, ne peut être gligé et c'est pourquoi nous avons, pour toutes nos hes de Concarneau, mis en parallèles la longueur s nuits et la hauteur de la mer (1927, p. 34 et 35, IV); mais, en l'absence de données précises qui mettent de calculer la puissance de pénétration des les lumineuses suivant l'inclinaison du soleil, nous iendrons seulement que ces variations se font dans même sens que celles de la température.

Celle-ci peut incontestablement exercer une action rable; elle offre en tout cas des variations saisonres qu'il est toujours possible de confronter avec phénomènes à longue périodicité. La courbe uelle des températures de surface prises à Conneau[1]) ne présente rien de spécial, si ce n'est parfois quelques chutes brusques journalières qui ne modifient pas son allure générale, parfaitement régulière, avec son maximum, vers 18°,5 C., dans le courant de juillet et son minimum, vers 8° C., dans le courant de décembre et répété parfois en février. Si l'on essaie de superposer cette courbe à celle de la fréquence de quelques-uns des organismes recueillis dans le plancton on aboutit à des conclusions un peu discordantes.

Les Mysidacés[1]) s'avèrent comme particulièrement indifférents aux variations saisonnières du thermomètre: Les *Siriella* sont aussi abondants en février, mars, avril qu'en août; le *Gastrosaccus Normani* erre dans le plancton d'août à décembre; le *Paramysis spiritus* et le *Mesopodopsis Slabberi* sont toutefois un peu plus sensibles et ont leur maximum en février, tandis que celui du *Gastrosaccus spinifer* se place en avril-mai.

Il en est de même pour les mâles des autres groupes. Nous avons recueilli ceux d'*Asterope mariae* en aussi grande abondance en décembre qu'en août, ceux du *Bodotria scorpioides*[2]) en avril et en août, ceux de *Nannastacus* et de *Cumella* en mai, en septembre et en décembre. Quelques espèces toutefois sont en apparence plus exigeantes: les mâles des *Urothoë marina, pulchra, Grimaldi*[3]) ne viennent en foule à la surface qu'à une saison où le thermomètre ne dépasse pas 11° C. et ceux du *Vauthompsonia cristata* se montrent seulement durant la période la plus chaude de l'année, en juin et juillet.

En revanche, les femelles qui, sauf exception, sont toujours beaucoup plus rares dans le plancton, paraissent subir davantage l'action de la température. Les femelles de nos deux Ostracodes font leur apparition en mai avec celles du *Bodotria scorpioides*, au moment où l'on récolte en surface les deux sexes du *Metaphoxus Fultoni*, du *Perioculodes longimanus*, du *Guernea coalita*, et les jeunes du *Phtisica marina* et du *Caprella acanthifera*. D'autres se montrent en fin septembre-

) Voir figure 5.

[1]) Voir figure 2.
[2]) Voir figure 4.
[3]) Voir figure 6.

octobre, ce sont celles de *Vauthompsonia, de Nototropis Schwammerdami*, du *Dexamine spinosa*, du *Tritaeta gibbosa.*

En somme, on constate surtout, avec l'indifférence des mâles de la plupart des espèces, une réaction plus accusée des femelles aux variations de la température; leur apparition dans le plancton débutant à l'une des deux périodes critiques qui se placent respectivement au mois de mai, et au mois d'octobre.

s'en trouver affectés. Il est remarquable, en effet, nos observations le montrent clairement, que le facteur agissant n'est pas ici un degré thermique particulier mais le changement d'allure qui se produit deux fois par an dans la courbe des températures. S'il en était autrement nous verrions, quelle que soit la saison, les essaimages d'une même espèce se répéter avec la même fréquence que celle des points isothermes de la courbe de surface. Or, il n'en est rien

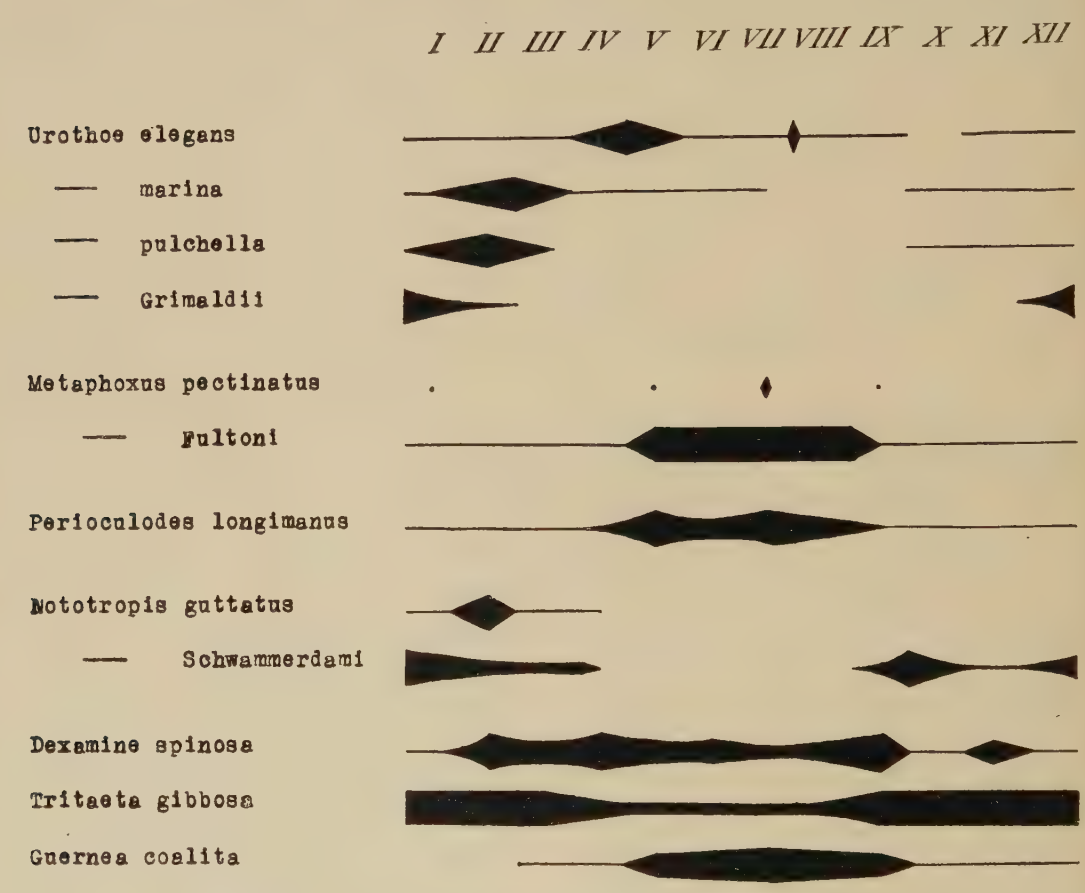

Fig. 6. Abondance relative et fréquence des Amphipodes dans le plancton nocturne de Concarneau.

Ces périodes sont critiques en ce sens qu'elles sont marquées, la première par une hausse rapide du thermomètre, qui partant à peine de 12° C., s'élève dans le même mois à 16°, et la seconde, par une chute correspondante, également accélérée, qui ramène le thermomètre à 12° C. Le mois de mai, dans la région de Concarneau, nous fait donc passer brusquement de l'hiver à l'été, tandis que le mois d'octobre nous replonge en hiver avec la même rapidité. Si l'on ajoute que ces variations peuvent être immédiatement ressenties par les espèces littorales auxquelles nous avons uniquement affaire, on comprend que leur métabolisme et, donc, leur comportement puissent

parmi les espèces qui essaiment en mai et dont le essaimages se reproduisent en octobre, nous ne pou vons citer que deux Cumacés, le *Nannastacus unguculatus* et le *Cumella pygmaea*, lesquels, presque tout l'année, même en décembre, abondent dans le plancto nocturne. Tout se passe donc, comme si la brusqu élévation ou, suivant les espèces, le brusque abaiss ment de la température annonçant un changemen de saison déclanchait une activité nouvelle des org nismes qu'on voit, alors, pour une durée plus c moins longue, reprendre avec régularité leurs migr tions verticales.

On pense, tout d'abord, à une action directe de

mpérature sur le phototropisme, mais celle-ci se rne généralement, quand la température s'élève, à ndre plus négatives encore les formes déjà négatives xquelles nous avons affaire. Sans négliger une reille action qui peut ainsi modifier la sensibilité à lumière, on ne voit point qu'elle suffise à rendre mpte d'un rythme saisonnier dont le déterminisme , en réalité beaucoup plus complexe.

* * *

Ce sont, en effet les facteurs internes qui mblent ici jouer un rôle prépondérant. MICHAEL 911), à qui l'on doit des recherches pleines d'in-êt sur les migrations verticales des *Sagitta*, avait à noté que "l'organisation, la constitution ou l'état ysiologique de chaque individu modifient l'influence la lumière, de la température et de la salinité sur comportement".

t de fait, nous avons vu que chez nos Crustacés, sensibilité des jeunes est en général différente de e des adultes et que les femelles ne se comportent , non plus, à cet égard, de même que les mâles. ns l'ensemble on peut dire que, au moins pour espèces vivant sur les fonds de sable ou de se, espèces strictement benthiques voire me fouisseuses, les grands rassemblements en face sont constitués presque uniquement par des les adultes. J'ai déjà signalé que ceux-ci ont des anes visuels beaucoup plus développés que ceux femelles et que certains, les Cumacés notamment, t incomparablement mieux armés pour la nage; nt en outre des organes des sens (allongement des ennes, calcéoles, etc.) qui font défaut à celles-ci, sont, ainsi, beaucoup plus sensibles aux ex-tions extérieures. Dès leur maturité, c'est-à-dire que sous l'influence des glandes génitales ils ont uis leurs caractères sexuels, ils sont à même de evoir aisément ces excitations auxquelles ils ré-dent en se libérant du fond et en participant, ce moment, aux migrations nocturnes. Certains ne, comme les mâles de nos Ostracodes, deviennent doute, à partir de ce moment, des pélagiques manents et se comportent comme tels. Les femelles, contraire, ne subissent point dans leur évolution modifications du même ordre: celles des Cumacés privées des puissantes rames que sont les pléo-es des mâles, et, d'une manière générale, les ter-aisons périphériques du système nerveux, sont elles apparemment moins développés. Leur uration sexuelle est beaucoup plus complexe et ompagne souvent de modifications profondes es de puberté et prémonitoires à la ponte, ation d'oostégites, etc.) corrélatives au déve-ement des ovaires. Et, pendant toute cette lente oration elles demeurent sur le sol, souvent en-s, sans que les excitations extérieures soient assez ment perçues pour vaincre la sensibilité au tact qui les retient dans le sable ou la vase. ais il arrive que ce changement de métabolisme t cependant à sensibiliser leur organisme. FRANCIS BERNARD (1932) étudiant le comportement de quelques Carabiques lucifuges, à œil régressé, constate que les femelles gravides ne fuient plus obstinément la lumière, "on remarque dans la nature, dit-il, que ce sont elles qui vivent le moins profondément enterrées: on les trouve au ras du sol, sous les pierres et les feuilles mortes, parfois courant au soleil, tandis que la plupart des autres individus se creusent des trous de quelques centimètres de profondeur". De même, chez nos Crustacés, à un changement physiologique, correspond une modification du comportement: les femelles d'Amphipodes que nous prenons en surface avec les mâles sont en pleine activité génitale avec des oostégites pourvus de soies sexuelles, et, le plus souvent portant des œufs fraichement pondus dans la poche incubatrice. Les Ostracodes, les Cumacés nous ont permis les mêmes constatations et nous avons noté, dans le groupe si varié des Isopodes, des différences de comportement en rapport avec l'éthologie sexuelle particulière à chaque espèce. Mais, dans tous ces cas, où l'on saisit nettement l'influence de la maturité sexuelle sur l'activité motrice des femelles, on est frappé néanmoins par la rareté de celles-ci dans le plancton, qui contraste avec l'abondance des mâles. Il s'agit là, incontestablement, de formes éminemment sédentaires auxquelles seulement des conditions vraiment exceptionnelles permettent de s'élever jusqu'à la surface. Qu'on se rappelle, à ce sujet, non seulement les expériences de laboratoire sur les Cumacés auxquelles il a été fait allusion plus haut, mais surtout les observations poursuivies la nuit, en mer. On y voit que dans les pêches nocturnes sans lumière toujours beaucoup plus pauvres en individus, le nombre des femelles par rapport à celui des mâles est, malgré tout, plus considérable que dans les pêches à la lanterne: les individus des deux sexes peuvent même s'y trouver à égalité (*Asterope mariae, Guernea coalita*). Et cela montre, pour le moins, l'indifférence des femelles à l'éclat de notre feu. S'il est insuffisant même pour orienter la nage d'individus errant déjà dans le plancton, à plus forte raison, comprenons-nous que les variations journalières d'éclairement soient impuissantes à les arracher du sol pendant leur phase de repos, et n'aient sur elles qu'une action bien restreinte, même dans le temps de leur activité motrice.

Chez les Crustacés, il y a donc une différence très sensible entre le comportement des espèces qui, comme la plupart des Mysidacés, par exemple, certains Isopodes (*Idotea*), certains Amphipodes (*Dexamine, Apherusa* etc.) demeurent à tous les stades de leur évolution en mouvement près du fond, ont des yeux également bien développés dans les deux sexes et celui des Ostracodes, des Cumacés, ou de la majorité de nos Amphipodes dont l'activité motrice est seulement déclanchée par la maturation sexuelle et dont les femelles ont des yeux sensiblement réduits. Les premiers se comportent comme des pélagiques permanents; leurs migrations peuvent intéresser les adultes des deux sexes, également sensibles aux variations d'éclairement et aussi, dans une certaine

mesure, les jeunes individus; les seconds ne sont sensibles à ces dernières que très inégalement: les mâles adultes y répondent avec constance, les femelles très rarement — accidentellement devrions-nous dire — et seulement à la faveur de l'agitation temporaire que leur communique l'accomplissement des fonctions de reproduction.

En somme, les modifications du métabolisme en relation avec le développement des gonades sont telles qu'il en résulte une activité motrice particulière des reproducteurs qu'oriente leur sensibilité accrue aux variations d'éclairement.

* * *

La relation entre ces deux phénomènes est parfois loin d'être aussi évidente chez nos Crustacés. Elle est en effet souvent masquée par l'évolution rapide des individus qui, adultes en peu de temps, sont ensuite capables de donner, chacun, plusieurs pontes successives. Les individus issus de ces générations différentes tout en évoluant pour leur propre compte se mélangent entre eux en proportions variées suivant les circonstances sans qu'il soit possible de les reconnaître dans les captures. Rappelons ce que les élevages de Bleg-vad (1922) nous ont appris sur le cycle vital de quelques-uns de nos Mysidacés: les individus du *Praunus flexuosus*, par exemple, ayant hiverné à l'éta

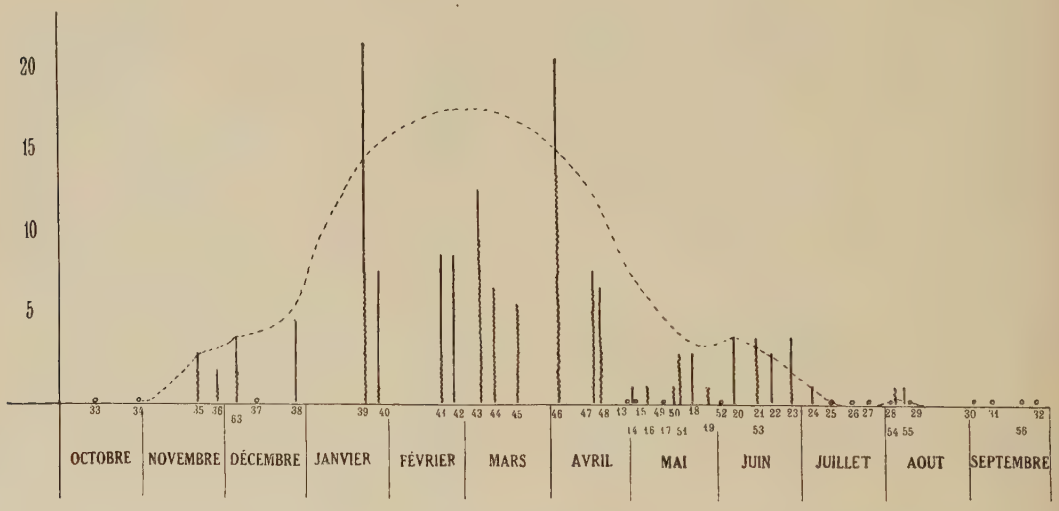

Fig. 7. Abondance relative et fréquence du *Nymphon gracile* dans le plancton nocturne de Concarneau. Les traits droits se rapportent aux ♂ et les traits ondulés aux ♀. Les nombres en abscisses correspondent aux numéros des pêches.

On se rappelle que Menke (1911) fait également appel à des modifications quotidiennes des échanges métaboliques pour expliquer les migrations verticales journalières. Sans prendre parti pour ou contre une hypothèse qui s'applique à un autre problème que celui discuté ici, nous sommes bien obligés de constater que le rythme saisonnier, qui tient ainsi sous sa dépendance les migrations verticales journalières, est, avant tout, un rythme sexuel. Et, de fait, chaque fois que nous avons pu préciser la durée de l'époque de ponte d'une espèce donnée, nous avons constaté qu'elle coïncidait avec le maximum d'abondance des individus dans le plancton.

Pour les Polychètes, la phase pélagique coïncide strictement avec la crise génitale et ne se produit pas en dehors d'elle; nous ne trouvons en surface que des reproducteurs bourrés de cellules sexuelles ou en partie vidés. Pour le *Nymphon gracile*, cette phase se situe, aussi, nettement au moment de la reproduction; les adultes seuls y participent et leur courbe de fréquence dans le plancton inscrit les variations de l'activité génitale (voir figure 7).

d'immatures donnent trois pontes successives; l'in cubation dure trois semaines environ et les jeunes issus des premières pontes, deviennent mûrs, à leu tour, au bout d'un mois et demi; ils peuvent, avan l'hiver, engendrer deux nouvelles générations. L *Paramysis spiritus* a un cycle analogue. Les Ostra codes, les Cumacés, les Amphipodes présentent de même des générations échelonnées dont les représen tants, adultes, viennent grossir peu à peu, ou rem placer les bandes planctoniques. Mais là, nous man quons le plus souvent des précisions qui seraient s nécessaires pour comprendre l'importance variable de groupements de reproducteurs en surface, et nou ignorons, en particulier, totalement quelle longévit il faut accorder à ceux-ci. Mais nous avons, au moin pour quelques espèces, d'excellentes raisons de croir que les mâles, une fois adultes, deviennent en quelqu sorte pélagiques permanents, c'est-à-dire, demeuren entre deux eaux, près du fond le jour, près de la sur face la nuit, tant que dure l'époque de la reproduction Si l'on pense à la rareté des femelles dans le plancton qui nous conduit à admettre que la fécondation doi

opérer la plupart du temps près du fond, comme la arrive même pour certains Polychètes (*Leptonereis glauca*), quand les mâles seuls, essaiment en urface; si l'on ajoute, enfin, que leurs mues obligaoires, avant et après la ponte, sont aussi autant de hases critiques dont nous ne savons pas les réperutions, on conviendra qu'il est ici particulièrement alaisé de percevoir avec détails la liaison ailleurs si ridente qui existe entre le rythme saisonnier des anifestations pélagiques et le rythme sexuel. Nous voyons se traduire par une succession de périodes repos et de périodes d'activité dont les poussées rrespondent, dans l'ensemble, aux périodes de repos d'activité des glandes génitales.

Et c'est là, par son action sur l'époque de la marité des produits génitaux, que l'on pourrait trouver nfluence indirecte de la température sur le rythme isonnier, puisqu'il existe des espèces qui se reproisent exclusivement en hiver, d'autres en été, et, autres, surtout dont l'époque de reproduction se odifie suivant la latitude.

Peut-être, faudra-t-il invoquer également, et pour même raison, l'influence de la lumière du jour ou la durée d'insolation qui est en rapport étroit avec variations saisonnières du *pH*. De très intéressantes ndes poursuivies principalement par J. R. Baker, M. Ranson, T. H. Bissonette et par M. A. H. NEKER (1932) tendent à montrer que la lumière a e action non douteuse sur la périodicité sexuelle. n plus, J. T. Cunningham (1932) invoque, à ce ppos, l'action des rayons polarisés de la lumière naire. Et, d'autre part, les recherches de Kofoïd le plancton de l'Illinois River montrent qu'il ste un cycle mensuel d'abondance en rapport avec succession des phases de la lune.

Je n'ajouterai rien cependant à ce que nous avons ailleurs (1927) de l'influence lunaire. En dépit ne ample moisson de faits nouveaux qui généralise ore le synchronisme constaté entre les phases de une et les phénomènes de reproduction — et dont istence ici montre bien que nous avons affaire à rythme sexuel — nous sommes toujours aussi orants sur la véritable nature de ces relations et le mécanisme suivant lequel pourrait s'établir dépendance réciproque entre ces deux phénnes. Ce synchronisme est d'une netteté remarquable z certains Polychètes et se retrouve à un moindre ré chez quelques Crustacés (*Iphinoë*, *Pseudocuma*, *Paraphoxus*, *Dexamine*). Si, à l'exemple de nos devanrs, nous avons rapporté leurs essaimages aux différentes phases lunaires, c'est sans préjuger d'une inence directe ou même indirecte de la lune; à défaut explication plausible, nous avons simplement conré ce chronomètre commode. Mais, de même que variations saisonnières nous fixent sur la durée et oque de la maturité sexuelle de l'espèce, il est sible que les variations à plus courte période, que nous rapportons aux phases lunaires, soient de même l'indice, pour les espèces qui s'y trouvent assujetties, que l'arrivée à maturité des individus se fait par poussées successives et régulièrement espacées, intéressant chaque fois un grand nombre d'entre eux.

* * *

En définitive, le rythme nycthéméral des espèces benthiques littorales étudiées ici, lié au fonctionnement du système nerveux, est déterminé par des réactions aux variations d'éclairement. Toute action ayant pour effet de modifier à ce point de vue la sensibilité des individus peut modifier l'allure de ce rythme. Les transformations internes liées au développement des gonades semblent ici jouer le premier rôle: en provoquant une activité motrice particulière des reproducteurs, qui se trouvent ainsi libérés du fond et se comportent dès lors comme les pélagiques permanents, la crise de maturation sexuelle explique la subordination du rythme nycthéméral à un rythme saisonnier à longues périodes, tandis qu'il faut chercher dans le métabolisme propre à chaque sexe et, accessoirement dans le dimorphisme qui en résulte, une explication de la prédominance si fréquente des mâles dans le plancton.

Par quel mécanisme se fait cette action mobilisatrice de la maturité sexuelle? Il s'agit là d'un phénomène extrêmement général que l'on constate à peu près dans tous les groupes et qui prend souvent — tel le cas des migrations génétiques — une ampleur considérable. C'est qu'en effet, au moment où s'achève leur maturité, le métabolisme des reproducteurs subit de telles modifications que ceux-ci se trouvent en état de déséquilibre avec le milieu. Avec une sensibilité exaltée, ils obéissent alors énergiquement, et dans la mesure où ce déséquilibre en est corrigé, aux sollicitations de facteurs externes qui jusque là les laissaient à peu près indifférents.

Pour les Polychètes, nous basant sur les observations de Treadwell notant une augmentation de la quantité de Co^2 éliminé par les œufs à l'approche de leur maturité et sur nos propres analyses montrant que les Néréidiens font pendant leurs transformations sexuelles et durant leur phase pélagique une consommation d'oxygène beaucoup plus considérable que pendant leur vie sédentaire, Legendre et moi pensons qu'on peut voir, dans la nécessité d'échanges respiratoires plus intenses une des causes qui déterminent ces formes à abandonner à ce moment leur retraite, sous les pierres, dans la vase ou le sable, pour nager entre deux eaux. Sans vouloir généraliser cette hypothèse, nous sommes persuadés qu'elle indique la voie à suivre, et qu'aucune explication ne saura nous satisfaire pleinement si elle ne tient compte du changement qui s'opère dans le métabolisme au moment de la maturité sexuelle.

Der Borsäuregehalt des Meerwassers und seine Bedeutung bei der Berechnung des Kohlensäuresystems im Meerwasser.

Ergänzung

zum Bericht über die im Frühjahr 1931 in Helsingfors von einer Arbeitskommission der Internationalen Meeresforschung ausgeführten Untersuchungen

von

Kurt Buch, Helsingfors.

Kurz nach Erscheinen des Berichtes »Über das Kohlensäuresystem im Meerwasser« von Buch, Harvey, Wattenberg und Gripenberg (2) wurde von V. M. Goldschmidt und Cl. Peters eine spektrographische Untersuchung über den Borgehalt des Meerwassers veröffentlicht, welche bewies, dass dieser bedeutend höher ist, als bisher allgemein angenommen wurde. Die neuerdings von verschiedenen Forschern angestellten quantitativen chemischen Analysen (Harvey und Moberg[1]), Wattenberg (8), Buch (3)) haben übereinstimmend ergeben, dass der Borgehalt proportional dem Chlorgehalte ist, wonach das Bor nach der ersten Behauptung von Goldschmidt und Peters sich als ein integrierender Bestandteil aller spezifischen marinen Grundstoffe erwiesen hat. Nach dem bisherigen analytischen Ergebnisse beträgt der Borgehalt in Promille angegeben.

$$B = 0.00024 \cdot Cl.$$

Dieser Borgehalt ist im Meerwasser teils in Form nichtdissoziierter Borsäure H_3BO_3, teils in Form des primären Ions H_2BO_3' zugegen. Die mögliche Bildung von Polyborationen ist, wie Buch (3, 4) gezeigt, höchstwahrscheinlich von ganz untergeordneter Bedeutung. Für die totale Borsäurekonzentration des Meerwassers

$$c_{\Sigma H_3BO_3} = c_{H_2BO_3'} + c_{H_3BO_3}$$

und gegeben in Millimolen pro Liter können wir folgende Näherungsrelation zum Chlorgehalte in Promille aufstellen.

$$c_{\Sigma H_3BO_3} = 0.0225 \cdot Cl\,{}^0/_{00}.$$

In einer physikalisch-chemischen Untersuchung hat Buch (3, 4) die Einwirkung der Borsäure auf das Kohlensäuregleichgewicht bestimmt. Bei dieser Untersuchung wurde zunächst die schon von der Kommission diskutierte Beobachtung bestätigt, dass Bestimmungen der scheinbaren zweiten Dissoziationskonstante der Kohlensäure in originalem Meerwasser und borfreiem Kunstwasser gleichen Salzgehaltes von einander etwas abweichende Werte ergaben. Da aber für die Abweichungen an der Hand der damaligen Kenntnisse über die Zusammensetzung des Meerwassers keine genügende Erklärung gefunden wurde, so musste die Frage einer späteren speziellen Untersuchung überlassen werden und die Kommission bis auf weiteres die an originalem Seewasser erhaltenen Daten verwerten. Die Entdeckung des verhältnismässig hohen Borsäuregehaltes brachte die gesuchte Erklärung eher als vermutet. Die erneuten Bestimmungen der zweiten Dissoziationskonstante an borsäurefreiem Wasser stimmten mit älteren von Buch (1) ausgeführten bestens überein, desgleichen auch mit Bestimmungen von E. G. Moberg und D. M. Greenberg[1]). Sie konnten nun zur quantitativen Bestimmung des Borsäureeinflusses verwertet werden. Die Resultate der bei 20° ausgeführten Bestimmungen an Wasserproben verschiedenen Chlorgehaltes ergaben folgende Beziehung

$$pK_2' = 10.45 - 0.682\sqrt[3]{Cl\,{}^0/_{00}} + 0.020 \cdot Cl\,{}^0/_{00},$$

wo pK_2' in derselben Weise wie im Berichte der Kommission definiert ist. In Beziehung gebracht zur thermodynamischen Konstante konnten auch neue Werte der Aktivitätskoeffizienten der CO_3''-Ionen auf demselben Wege, wie im Berichte der Kommission angegeben, berechnet werden. Die Bestimmungen der Aktivitätskoeffizienten der HCO_3'-Ionen sowie die der Dissoziationskonstanten der ersten Dissoziationsstufe der Kohlensäure blieben von der Anwesenheit der Borsäure unberührt. Tabelle 1 enthält die neuen Aktivitätskoeffizienten $f_{CO_3''}$ sowie deren negative Logarithmen $pf_{CO_3''}$ bei verschiedenen

[1]) Hardings und Mobergs in Scripps Institution, La Californien, ausgeführten Untersuchungen sind dem Verf. brieflich durch Vermittelung von Prof. T. W. Vaughan und Dr. H. Wattenberg mitgeteilt.

[1]) Brieflich durch Vermittelung von Prof. T. W. Vaughan und Dr. H. Wattenberg mitgeteilt.

Tabelle 1.

Cl ‰	2	4	6	8	10	12	14	16	18	20	22
$pf_{CO_3''}$	1.03	1.275	1.43	1.55	1.64	1.71	1.76	1.82	1.86	1.90	1.93
$f_{CO_3''}$	0.093	0.054	0.037	0.029	0.023	0.020	0.017	0.015	0.014	0.013	0.01

Tabelle 2.

enthaltend Werte für pK_2' der Kohlensäure bei verschiedenen Temperaturen und Cl-Gehalten

Cl ‰ $t°$	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
0.....	10.68	.66	.63	.61	.58	.56	.54	.51	.49	.47	.45	.42	.40	.38	.36	.34
1.....	10.02	9.99	.97	.94	.92	.90	.87	.85	.83	.81	.78	.76	.74	.72	.70	.68
2.....	9.87	.84	.81	.79	.77	.74	.72	.70	.67	.65	.63	.61	.59	.56	.54	.52
3.....	9.76	.73	.71	.68	.66	.64	.61	.59	.57	.55	.52	.50	.48	.46	.44	.42
4.....	9.68	.65	.63	.60	.58	.56	.53	.51	.49	.47	.44	.42	.40	.38	.36	.34
5.....	9.62	.59	.56	.54	.52	.49	.47	.45	.42	.40	.38	.36	.34	.32	.29	.27
6.....	9.56	.54	.51	.49	.46	.44	.42	.39	.37	.35	.33	.30	.28	.26	.24	.22
7.....	9.52	.49	.46	.44	.42	.39	.37	.35	.32	.30	.28	.26	.24	.22	.19	.17
8.....	9.48	.45	.42	.40	.38	.35	.33	.31	.28	.26	.24	.22	.20	.18	.15	.13
9.....	9.44	.41	.39	.36	.34	.32	.29	.27	.25	.23	.21	.18	.16	.14	.12	.10
10.....	9.41	.38	.36	.33	.31	.29	.26	.24	.22	.20	.17	.15	.13	.11	.09	.07
11.....	9.38	.36	.33	.31	.28	.26	.24	.21	.19	.17	.15	.12	.10	.08	.06	.04
12.....	9.36	.33	.31	.28	.26	.24	.21	.19	.17	.14	.12	.10	.08	.06	.04	.02
13.....	9.34	.31	.29	.26	.24	.21	.19	.17	.14	.12	.10	.08	.06	.04	.02	.00
14.....	9.32	.30	.27	.24	.22	.20	.17	.15	.13	.11	.09	.07	.04	.02	.00	8.98
15.....	9.30	.27	.25	.22	.20	.18	.15	.13	.11	.09	.06	.04	.02	.00	8.98	.96
16.....	9.28	.26	.23	.21	.18	.16	.14	.11	.09	.07	.05	.02	.00	8.98	.96	.94
17.....	9.27	.24	.22	.19	.17	.14	.12	.10	.08	.05	.03	.01	8.99	.97	.95	.93
18.....	9.26	.23	.20	.18	.15	.13	.11	.09	.06	.04	.02	.00	8.97	.95	.93	.91
19.....	9.24	.21	.19	.16	.14	.12	.10	.07	.05	.03	.01	8.98	.96	.94	.92	.90
20.....	9.23	.20	.18	.15	.13	.11	.08	.06	.04	.02	8.99	.97	.95	.93	.91	.89
21.....	9.22	.19	.17	.14	.12	.10	.07	.05	.03	.01	8.98	.96	.94	.92	.90	.88
22.....	9.21	.19	.16	.14	.11	.09	.06	.04	.02	.00	8.97	.95	.93	.91	.89	.87

Tabelle 3.

enthaltend Werte für pK_B' der Borsäure bei verschiedenen Temperaturen und Cl-Gehalten.

Cl ‰ $t°$	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
0.....	9.39	.38	.36	.34	.32	.30	.29	.27	.25	.24	.22	.20	.19	.17	.16	.14
1.....	9.26	.24	.22	.20	.19	.17	.15	.14	.12	.10	.09	.07	.05	.04	.02	.01
2.....	9.22	.20	.18	.17	.15	.13	.11	.10	.08	.06	.05	.03	.01	.00	8.98	.97
3.....	9.19	.17	.15	.14	.12	.10	.08	.07	.05	.03	.02	.00	8.98	.97	.95	.94
4.....	9.16	.14	.13	.11	.09	.07	.06	.04	.02	.01	8.99	.97	.96	.94	.93	.91
5.....	9.14	.12	.10	.08	.07	.05	.03	.01	.00	8.98	.97	.95	.93	.92	.90	.89
6.....	9.12	.10	.08	.06	.05	.03	.01	8.99	.98	.96	.94	.93	.91	.90	.88	.87
7.....	9.10	.08	.06	.04	.03	.01	8.99	.97	.96	.94	.92	.91	.89	.88	.86	.85
8.....	9.08	.06	.04	.02	.01	8.99	.97	.95	.94	.92	.91	.89	.87	.86	.84	.83
9.....	9.06	.04	.02	.00	8.99	.97	.95	.94	.92	.90	.89	.87	.85	.84	.82	.81
10.....	9.04	.02	.01	8.99	.97	.95	.93	.92	.90	.88	.87	.85	.84	.82	.81	.79
11.....	9.03	.01	8.99	.97	.95	.93	.92	.90	.88	.87	.85	.83	.82	.80	.79	.77
12.....	9.01	8.99	.97	.95	.93	.92	.90	.88	.87	.85	.83	.82	.80	.79	.77	.76
13.....	8.99	.97	.96	.94	.92	.90	.89	.87	.85	.83	.82	.80	.79	.77	.76	.74
14.....	8.98	.96	.94	.92	.90	.89	.87	.85	.84	.82	.80	.79	.77	.76	.74	.73
15.....	8.96	.94	.92	.91	.89	.87	.85	.84	.82	.81	.79	.77	.75	.74	.72	.71
16.....	8.95	.93	.91	.89	.87	.86	.84	.82	.81	.79	.77	.76	.74	.72	.71	.70
17.....	8.93	.91	.89	.88	.86	.84	.82	.81	.79	.77	.76	.74	.72	.71	.69	.68
18.....	8.92	.90	.88	.86	.84	.83	.81	.79	.78	.76	.74	.73	.71	.70	.68	.67
19.....	8.90	.88	.87	.85	.83	.81	.79	.78	.76	.74	.73	.72	.70	.68	.67	.65
20.....	8.89	.87	.85	.83	.81	.80	.78	.76	.75	.73	.71	.70	.68	.67	.65	.64
21.....	8.88	.86	.84	.82	.80	.78	.77	.75	.73	.72	.70	.68	.67	.65	.64	.62
22.....	8.86	.84	.82	.81	.79	.77	.75	.74	.72	.70	.69	.67	.65	.64	.62	.61

orgehalten, welche nun an Stelle der ursprüng-
en Werte der Kommission (Tabelle 15 S. 15) zu
zen sind. (Tabelle 1).
Zur Berechnung der Konstanten bei anderen Tem-
aturen konnten die Methoden der Kommission
erändert übernommen werden. Es wurde also eine
ue Tabelle von pK_2'-Werten bei verschiedenen
nperaturen und Chlorgehalten berechnet, welche
ftig an Stelle der ursprünglichen Tabelle der Kom-
sion zu setzen ist. (Tabelle 2).
Die weiteren Untersuchungen zur Feststellung des
säure-Einflusses bestanden in Bestimmungen der
einbaren Dissoziationskonstante der Borsäure in
rwasserproben verschiedenen Salzgehaltes, in
en der Borgehalt vorher bestimmt war. Um ge-
ere Resultate zu erhalten wurde der Borgehalt
er Proben durch Zusatz geringer Mengen Borax-
säurepuffers erhöht. Das Ergebnis dieser Bestim-
ngen liess sich durch eine Gleichung dritten
des darstellen

$$pK_B' = 9.22 - 0.123\sqrt[3]{Cl^0/_{00}} - 0.0086 \cdot Cl^0/_{00}.$$

ur Bestimmung des Temperatureinflusses wurden
von H. Lundén bei verschiedenen Temperaturen
eführten Messungen der thermodynamischen
stante verwertet. Mit Hilfe dieser und der obigen
chung wurde auch für die Borsäure eine Tabelle
scheinbaren Konstante bei verschiedenen Tem-
turen ausgerechnet. (Tabelle 3).

echnung der Einwirkung der Borsäure auf das Kohlensäuregleichgewicht.

e Einwirkung der Borsäure auf das Kohlensäure-
lhgewichtssystem in der Darstellungsweise der
mission gibt sich in der Titrations-Alkalinität zu
nnen. Im Berichte der Kommission war voraus-
zt, dass diese ausschliesslich aus den mit den
n der Kohlensäure äquivalenten Anzahl Basen
mmengesetzt war

$$\text{Titr.-Alk.} = c_{HCO_3'} + 2c_{CO_3''}.$$

tsächlich ist in derselben aber auch die den
säureionen entsprechende Basenmenge
lten. Eine theoretisch einwandfreie Darstellung
ten wir an der Hand der Gleichung, welche in
Lösung von Kohlensäure, Borsäure und ent-
henden Basen die Gleichheit der Summe von
ven und negativen Ionen-Äquivalenten angibt:

$$\text{Total-Alk.} = c_{HCO_3'} + 2c_{CO_3''} + c_{H_2BO_3'} + c_{OH'}$$
$$= \text{Titr.-Alk.} + c_{H\cdot}$$

en richtigen Wert der Titrations-Alkalinität bei
senheit von Borsäure erhalten wir titrimetrisch
ann, wenn die Titration auf einem so sauren
rexponenten bewerkstelligt wird, dass alle Bor-
säure frei in nichtdissoziierter Form zugegen ist. Dies ist der Fall bei pH etwa = 6. Wird mit Farbenindikatoren titriert, so ist ein zweckmässiger Indikator Methylrot oder noch besser der von Wattenberg (7) eingeführte Mischindikator Methylrot-Chresolgrün. Definieren wir

2) $$c_{HCO_3'} + 2c_{CO_3''} = \text{Karbonat-Alkalinität}$$

und lösen obige Gleichung 1 in Bezug auf diese auf, so erhalten wir

3) $$\text{Karb.-Alk.} = \text{Titr.-Alk.} - c_{H_2BO_3'} - (c_{H\cdot} - c_{OH'})$$

Die eingeklammerte Differenz der H·- und OH'-Ionen kann fast stets (bei $pH < 8.5$) vernachlässigt werden.

Die verschiedenen Kohlensäurekonstituenten können nun nach demselben Verfahren und mit denselben Voraussetzungen, wie im Berichte der Kommission (Kapitel VIII) angegeben, berechnet werden, nämlich an der Hand einer Bestimmung der Titrations-Alkalinität und pH bei bekannten $Cl^0/_{00}$ und $t°$-Werten, wenn wir in allen Gleichungen, wo die Titr.-Alk. vorkommt, diese Grösse durch Karb.-Alk. ersetzen. Ausserdem ist nunmehr K_2' der neuen hier angegebenen Tabelle zu entnehmen.

Für die Berechnung von Karb.-Alk. gemäss Gl. 3 ist die Berechnung von $c_{H_2BO_3'}$ nötig, welch letztere wir wiederum aus der Dissoziationsgleichung

$$\frac{a_{H\cdot} \cdot c_{H_2BO_3'}}{c_{\Sigma H_3BO_3} - c_{H_2BO_3'}} = K_B'$$

erhalten. So gelangen wir schliesslich zu folgendem Ausdruck für die Karbonat-Alkalinität

$$\text{Karb.-Alk.} = \text{Titr.-Alk.} - \frac{K_B' \cdot c_{\Sigma H_3BO_3}}{a_{H\cdot} + K_B'},$$

welche nur bekannte Grössen enthält.

In dem Berechnungsschema der Kommission (Kap. VIII) sind auch zur Vereinfachung der Berechnungen die Hilfskonstanten

$$k_{HCO_3'} = \frac{1}{1 + \frac{2K_2'}{a_{H\cdot}}}, \quad \text{und} \quad k_{CO_3''} = \frac{a_{H\cdot} k_{HCO_3'}}{K_2'}$$

eingeführt, nebst einer Tabelle zu ihrer Berechnung bei Kenntnis der Differenz $pK_2' - pH$. Diese Tabelle bleibt von der Borsäure unberührt und kann unverändert (natürlich mit den neuen K_2'-Werten) angewandt werden.

Im Berichte der Kommission wurde ein Tabellensystem gegeben sowie eine Interpolationstafel zur direkten Entnahme von ΣCO_2 und pCO_2 bei bestimmten $Cl^0/_{00}$ und $t°$. Eine Durchrechnung des

Tabelle 4.

pH	$t = 0°$					$t = 5°$					$t = 10'$				
	$Cl\,‰ =$	15.0	16.5	18.0	19.5	21.0	15.0	16.5	18.0	19.5	21.0	15.0	16.5	18.0	19.5	21.0
	Titr.-Alk. =	1.84	2.03	2.21	2.40	2.58	1.84	2.03	2.21	2.40	2.58	1.84	2.03	2.21	2.40	2.58
																Karbonat-
7.6		1.83	2.01	2.20	2.38	2.56	1.83	2.01	2.19	2.38	2.56	1.83	2.01	2.19	2.37	2.55
7.7		1.83	2.01	2.19	2.37	2.55	1.82	2.01	2.19	2.37	2.55	1.82	2.00	2.19	2.37	2.55
7.8		1.82	2.00	2.18	2.37	2.55	1.82	2.00	2.18	2.36	2.54	1.82	2.00	2.18	2.36	2.54
7.9		1.82	2.00	2.18	2.36	2.54	1.81	2.00	2.17	2.35	2.53	1.81	1.99	2.17	2.35	2.53
8.0		1.81	1.99	2.17	2.35	2.53	1.81	1.99	2.16	2.34	2.52	1.80	1.98	2.16	2.34	2.51
8.1		1.80	1.98	2.16	2.34	2.51	1.80	1.98	2.15	2.33	2.51	1.79	1.97	2.15	2.32	2.50
8.2		1.79	1.97	2.15	2.32	2.50	1.79	1.96	2.14	2.32	2.49	1.78	1.96	2.13	2.31	2.48
8.3		1.78	1.96	2.13	2.31	2.48	1.78	1.95	2.12	2.30	2.47	1.77	1.94	2.12	2.29	2.46
8.4		1.77	1.94	2.12	2.29	2.46	1.76	1.94	2.11	2.28	2.45	1.76	1.93	2.10	2.27	2.44
8.5		1.75	1.93	2.10	2.27	2.44	1.75	1.92	2.09	2.26	2.43	1.74	1.91	2.08	2.25	2.42
																Totalkohlens
7.6		1.86	2.04	2.22	2.40	2.58	1.84	2.03	2.20	2.38	2.55	1.83	2.01	2.19	2.36	2.54
7.7		1.84	2.01	2.19	2.37	2.54	1.82	2.00	2.17	2.35	2.52	1.81	1.98	2.16	2.33	2.50
7.8		1.81	1.98	2.16	2.33	2.50	1.79	1.97	2.14	2.31	2.48	1.78	1.95	2.12	2.29	2.46
7.9		1.78	1.95	2.12	2.30	2.46	1.77	1.94	2.10	2.27	2.44	1.75	1.92	2.08	2.25	2.42
8.0		1.75	1.92	2.09	2.26	2.42	1.74	1.90	2.06	2.23	2.39	1.72	1.88	2.04	2.20	2.37
8.1		1.72	1.88	2.05	2.21	2.37	1.70	1.86	2.02	2.18	2.34	1.68	1.84	1.99	2.15	2.31
8.2		1.69	1.85	2.00	2.16	2.32	1.66	1.82	1.97	2.13	2.28	1.64	1.79	1.94	2.10	2.24
8.3		1.64	1.80	1.95	2.11	2.26	1.62	1.77	1.92	2.07	2.21	1.59	1.74	1.89	2.03	2.17
8.4		1.60	1.75	1.90	2.05	2.19	1.57	1.72	1.86	2.00	2.15	1.54	1.69	1.83	1.96	2.10
8.5		1.55	1.69	1.84	1.98	2.11	1.52	1.66	1.80	1.93	2.07	1.49	1.63	1.76	1.89	2.02
																Kohlensäured
7.6		9.7	10.4	11.0	11.7	12.3	10.4	11.2	11.8	12.5	13.2	11.2	11.9	12.7	13.4	14.1
7.7		7.6	8.2	8.7	9.2	9.7	8.2	8.8	9.3	9.8	10.4	8.8	9.4	9.9	10.5	11.0
7.8		6.0	6.4	6.8	7.2	7.5	6.4	6.8	7.2	7.6	8.1	6.8	7.3	7.7	8.1	8.5
7.9		4.7	5.0	5.3	5.6	5.9	5.0	5.3	5.6	6.0	6.2	5.3	5.7	6.0	6.3	6.6
8.0		3.6	3.9	4.1	4.3	4.5	3.9	4.1	4.3	4.6	4.8	4.1	4.3	4.6	4.8	5.1
8.1		2.8	3.0	3.1	3.3	3.5	2.9	3.1	3.3	3.5	3.7	3.1	3.3	3.5	3.7	3.8
8.2		2.2	2.3	2.4	2.5	2.7	2.3	2.4	2.5	2.7	2.8	2.4	2.5	2.7	2.8	2.9
8.3		1.6	1.7	1.8	1.9	2.0	1.7	1.8	1.9	2.0	2.1	1.8	1.9	2.0	2.1	2.2
8.4		1.2	1.3	1.4	1.5	1.5	1.3	1.4	1.4	1.5	1.6	1.4	1.4	1.5	1.6	1.6
8.5		0.9	1.0	1.0	1.1	1.1	0.9	1.0	1.1	1.1	1.2	1.0	1.0	1.1	1.1	1.2

Systems ergab, dass diese Werte zum Teil einer Korrektur bedürfen. Da die Grösse dieser Korrektur jedoch in komplizierter Weise von $Cl\,‰$ und $t°$ abhing, wurde es vorgezogen, statt Korrekturfaktoren auszurechnen eine vollständig neue Tabelle auszuarbeiten, welche nun die ursprüngliche Tabelle der Kommission zu ersetzen hat.

Dieselbe enthält ebenso wie die frühere: Totalkohlensäure, angegeben in Millimolen pro Liter, Kohlensäuredruck, angegeben in zehntausendstel Atmosphären, ausser dem aber noch die Karbonat-Alkalinität, in Milliäquivalenten pro Liter, definiert durch Gleichung 2; sämtliche Grössen bei den Temperaturen 0°, 5°, 10°, 15°, 20°, 25°, 30° und den Chlorgehalten 15 ‰, 16.5 ‰, 18 ‰, 19.5 ‰ und 21 ‰ für den pH-Bereich 7.6—8.5 in Intervallen von 0.1 Einheiten. Die Tabelle ist ebenso wie die ursprüngliche berechnet unter Voraussetzung der Gültigkeit der Relation

$$\text{Titr.-Alk.} = 0.123 \cdot Cl\,‰$$

und kann naturgemäss unverändert angewandt werden, nur wenn diese wirklich zutreffend ist. Treten Abweichungen ein, so wird nach den Angaben im Berichte S. 60 korrigiert. Für die Totalkohlensäure und den Kohlensäuredruck ist auch eine neue Interpolationstafel ausgearbeitet worden.

Tabelle 4.

	$t = 20°$					$t = 25°$					$t = 30°$				
21.0	15.0	16.5	18.0	19.5	21.0	15.0	16.5	18.0	19.5	21.0	15.0	16.5	18.0	19.5	21.0
2.58	1.84	2.03	2.21	2.40	2.58	1.84	2.03	2.21	2.40	2.58	1.84	2.03	2.21	2.40	2.58
ıte pro Liter.															
2.55	1.82	2.00	2.19	2.37	2.55	1.83	2.00	2.18	2.36	2.54	1.82	2.00	2.18	2.36	2.54
2.54	1.82	2.00	2.18	2.36	2.54	1.82	2.00	2.18	2.36	2.54	1.82	2.00	2.17	2.35	2.53
2.53	1.81	1.99	2.17	2.35	2.53	1.81	1.99	2.17	2.35	2.52	1.81	1.99	2.16	2.34	2.52
2.52	1.80	1.98	2.16	2.34	2.52	1.80	1.98	2.16	2.34	2.51	1.80	1.98	2.15	2.33	2.51
2.51	1.80	1.97	2.15	2.33	2.50	1.79	1.97	2.15	2.32	2.50	1.79	1.97	2.14	2.32	2.49
2.49	1.78	1.96	2.14	2.31	2.48	1.78	1.96	2.13	2.30	2.48	1.78	1.95	2.13	2.30	2.47
2.47	1.77	1.95	2.12	2.29	2.46	1.77	1.94	2.12	2.29	2.46	1.76	1.94	2.11	2.28	2.45
2.45	1.76	1.93	2.10	2.27	2.44	1.75	1.93	2.10	2.27	2.44	1.75	1.92	2.09	2.26	2.42
2.43	1.74	1.91	2.08	2.25	2.42	1.74	1.91	2.08	2.24	2.41	1.73	1.90	2.07	2.24	2.40
2.40	1.72	1.89	2.06	2.23	2.39	1.72	1.89	2.06	2.22	2.39	1.72	1.88	2.05	2.21	2.38
Liter.															
2.52	1.81	1.98	2.15	2.33	2.49	1.80	1.97	2.14	2.32	2.48	1.79	1.96	2.12	2.30	2.46
2.48	1.78	1.95	2.12	2.29	2.45	1.77	1.94	2.11	2.27	2.44	1.76	1.92	2.09	2.25	2.42
2.44	1.75	1.92	2.08	2.25	2.41	1.74	1.90	2.06	2.23	2.39	1.72	1.88	2.05	2.21	2.37
2.39	1.72	1.88	2.04	2.20	2.36	1.70	1.86	2.02	2.18	2.34	1.68	1.84	2.00	2.16	2.31
2.34	1.67	1.83	1.99	2.15	2.30	1.66	1.82	1.97	2.12	2.28	1.64	1.79	1.94	2.10	2.24
2.28	1.63	1.79	1.94	2.09	2.24	1.62	1.76	1.91	2.06	2.21	1.59	1.74	1.88	2.03	2.17
2.21	1.59	1.74	1.88	2.03	2.17	1.57	1.71	1.85	1.99	2.13	1.54	1.68	1.82	1.96	2.09
2.14	1.54	1.68	1.82	1.96	2.09	1.52	1.65	1.79	1.92	2.05	1.49	1.62	1.75	1.88	2.01
2.06	1.48	1.62	1.75	1.88	2.01	1.46	1.59	1.72	1.85	1.98	1.43	1.56	1.68	1.81	1.93
1.97	1.42	1.55	1.68	1.80	1.92	1.40	1.52	1.64	1.76	1.88	1.36	1.48	1.61	1.73	1.84
el Atmosphären.															
.9	12.4	13.3	14.1	14.8	15.5	13.2	14.1	14.9	15.8	16.6	14.0	14.8	15.7	16.5	17.3
.6	9.7	10.4	11.0	11.5	12.2	10.3	11.0	11.6	12.3	12.9	10.9	11.5	12.2	12.8	13.4
.0	7.5	8.0	8.5	8.8	9.3	8.0	8.4	8.9	9.4	9.9	8.4	8.8	9.4	9.8	10.3
.9	5.8	6.2	6.5	6.9	7.2	6.1	6.5	6.9	7.2	7.6	6.4	6.8	7.1	7.5	7.8
.3	4.4	4.7	5.0	5.2	5.5	4.7	4.9	5.2	5.5	5.8	4.9	5.2	5.4	5.7	5.9
.0	3.3	3.5	3.7	3.9	4.1	3.5	3.7	3.9	4.1	4.3	3.7	3.8	4.0	4.2	4.4
.0	2.5	2.7	2.8	3.0	3.1	2.6	2.8	2.9	3.1	3.2	2.7	2.9	3.0	3.1	3.3
.3	1.9	2.0	2.1	2.2	2.3	2.0	2.1	2.2	2.3	2.4	2.0	2.1	2.2	2.3	2.4
.7	1.4	1.5	1.6	1.6	1.7	1.4	1.5	1.6	1.7	1.7	1.5	1.5	1.6	1.7	1.7
.2	1.0	1.1	1.1	1.1	1.2	1.0	1.1	1.1	1.2	1.2	1.1	1.1	1.2	1.2	1.2

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